Italian registry of cardiac magnetic resonance

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Abbreviations: CAD, coronary artery disease; CMP, cardiomyopathy; CMR, cardiac magnetic resonance; SIRM, Italian Society of Medical Radiology.

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1. Introduction

CMR has evolved in recent years from an effective research tool into a clinically proven, safe and comprehensive imaging modality, with established guidelines and appropriateness criteria covering a wide spectrum of clinical indications and an increasing number of centers organizing fully dedicated scanning sessions being carried out either by radiologists and/or cardiologists [1,2]. Most information about its use and diagnostic performances however, is currently derived from very few large clinical trials or from selected populations enrolled in highly specialized centers with relatively limited knowledge of its day-to-day utilization.

The only available register is the EuroCMR, which was recently completed with 27,000 patients and was promoted and organized by the European Society of Cardiology Working Group of “Cardiovascular Magnetic Resonance”, with obvious predominant involvement of CMR-dedicated cardiological centers [3–5].

EuroCMR results convincingly showed that the exam has evolved from the status of “a niche modality” [6] with limited number of cases performed by few tertiary/academic referral into a routine imaging modality, homogeneously diffused and representing an extremely valuable diagnostic support to solve common clinical problems [3,4].

The Italian registry of CMR is an open-access study (no restriction criteria or proof of specific competence were required to participating centers) which was set up to provide a national overview of its utilization, offering a more “radiological” point of view of its current clinical role in daily practice, and was promoted by the sub-society of cardiac radiology of SIRM (Società Italiana di Radiologia Medica), which has currently almost 700 members (www.sirm.org/sottositi/cardio).

Forty different centers were involved in this multicenter and multivendor registry, which sought to evaluate clinical indications, spectrum of acquisition protocols, impact on clinical decision-making and safety profile of CMR.

2. Materials and methods

2.1. Data collection

The data were prospectively collected during a 6-month period (January–June 2011) and included a population of 3376 consecutive patients who underwent CMR in one of the 40 participating sites.

Centers were initially recruited via email from the mailing list of the SIRM members (approximately 8000 members) and each site, after acceptance, appointed a referral physician (radiologist or cardiologist) who was locally responsible for the data integrity, interpretation and collection and represented the direct contact for the steering committee of the study.

Referral physicians were not required to exhibit any specific sub-specialty based certificate of competency in CMR imaging as the aim of present registry was to provide a realistic “snapshot” of CMR utilization in Italy, without limiting patient’s enrollment only to most-experienced national groups.

Similarly, acquisition protocols were individually defined and tailored by each center according to the main clinical request, without following any established, predefined standardized protocol.

2.2. Patients form

A preliminary general report and a case-report form (CRF) were completed in each center.

In each electronic form, the following sections had to be filled:

(1) Patient’s data, including demographics, patient’s source (outpatient, day hospital or hospitalized) and clinical priority (defined as urgent vs. elective exam).

(2) Clinical indications to the exam, which were listed and readapted following the ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR Appropriateness criteria for cardiac computed tomography and cardiac magnetic resonance imaging published

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in 2006 and using the same organization proposed in the EuroCMR study, in order to obtain reproducible and comparable data [7].

3) Acquisition data concerning model and field strength of the scanner adopted, type and dose of contrast agents adopted and presence/absence (and type of drug) of pharmacological stress.

4) Adverse events occurring during or immediately after the examination, attributable to contrast agent administration and/or pharmacological stress and/or patient’s basal condition. Complications caused by acute adverse reactions to contrast media (i.e. within 60 min after administration) were defined according to the American College of Radiology criteria [8]. Incidents were scored as mild, moderate or severe using the following predefined criteria readapted from Dorfman et al. [9]:

(a) Mild: Transient change in condition, not life threatening and rapidly returning to baseline, required monitoring and/or minor intervention such as holding a medication, obtaining lab test(s), application of heat or cold.

(b) Moderate: Transient change in condition, may be life threatening if not treated, returning to baseline if properly treated and required monitoring and/or intervention such as reversal agent, additional medication, or transfer to ICU.

(c) Severe: Change in condition, life threatening if not treated and potentially permanent, may have required hospitalization or transfer to ICU, required monitoring and/or major intervention such as invasive procedure, intubation, hemodynamic support and blood transfusion. In case of death, patients were excluded from the registry, recording cause of the exitus.

5) Image quality of the exam was also evaluated on a 5-point scale from excellent to inadequate as follows:

(1) insufficient: defined as “major artifacts exist leading to non-diagnostic images”;
(2) ‘poor’ defined as “major artifacts present limiting clinical use of images”;
(3) ‘fair’ defined as “borderline clinical use due to adequate image quality”;
(4) ‘good’ defined as “only minor artifacts present with no/minimal impact on clinical use”;
(5) ‘excellent’ defined as “no artifacts”.

6) Result of the exam according to the main clinical request (i.e. positive, negative or non-diagnostic/inconclusive).

7) Clinical impact on patient’s management (meaning therapeutic impact or requiring further management) which was assessed by the local referral physician in consensus with patient’s referring physician and classified as follows:

(a) Non diagnostic or inconclusive exam.
(b) Relevant but without impact on patient’s management.
(c) Relevant with impact on patient’s management, consisting in changes in the therapeutic (pharmacological or surgical) or diagnostic (further procedures performed) management and/or patient’s discard or hospitalization following the exam.

8) Specialty of the reading and reporting physician.

3. Data extraction

All the data were collected via email on a monthly basis by trained personnel and manually stored in an electronic database provided by the University of L’Aquila for evaluation (Microsoft Excel version 2007).

Table 1
Demographic, clinical and acquisition data.

<table>
<thead>
<tr>
<th>Study population (n)</th>
<th>3376 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic distribution of participating centers and % of patient’s enrolled</td>
<td>- 21 North (46.3%)</td>
</tr>
<tr>
<td>- 14 Center (36.8%)</td>
<td></td>
</tr>
<tr>
<td>- 5 South and Islands (16.9%)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male: 2254 (67.0%); Female: 1122 (33.0%)</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>47.2 ± 19.3 (1–92)</td>
</tr>
<tr>
<td>Body mass index [kg/m²]</td>
<td>24.8 ± 2.2 (21.6–27.4)</td>
</tr>
<tr>
<td>Patient’s source</td>
<td>Outpatients: 2070 (61.0%); Day hospital: 232 (7.0%); Hospitalized: 1050 (31.0%); Non-specified: 23 (1.0%)</td>
</tr>
<tr>
<td>Clinical priority</td>
<td>Urgent: 6.5%; Elective (93.5%)</td>
</tr>
<tr>
<td>Scanner type (patient’s enrolled and %)</td>
<td>1.0 T: 25 (0.7%); 1.5 T: 3237 (96.5%); 3.0 T: 92 (2.8%)</td>
</tr>
</tbody>
</table>

4. Statistical analysis

Due to the descriptive nature of present registry, all collected data are expressed in terms of absolute numbers and corresponding percentages using means with standard deviation (SD) when appropriate. This study was approved by local institutional review boards.

5. Results

5.1. Patient’s data

Database of present registry includes 3376 patients who were prospectively enrolled during the study period.

The average number of patients enrolled per center was 84.4 ± 57.3 SD with a range between 3 and 425.

Mean age (SD) was 47.2 ± 19 years, range 1–92 years: 2254 (67.0%) patients were males and 1122 (33.0%) were female.

Concerning geographic distribution of patient’s population, there was a clear north-to-south gradient, with the largest proportion of patients (46.3%) enrolled from the north of the country (46.3%) followed by central regions (36.8%) whereas south and islands contributed for 16.8% of overall population.

Detailed patients’ data, are reported in Table 1.

Clinical priority to the exam was defined urgent in 6.5% of patients and elective in 91.6% of cases whereas no information was available in the remaining 1.8%.

Urgent exams were mostly required for the evaluation of acute patients (myocarditis and acute infarct patients in 70% of cases) or following a surgical procedure (21%).

Most of the examinations (2094 patients; 62.0%) were performed for outpatients, 232 were in a day hospital (7.0%) regimen and 1050 were hospitalized (31.0%).

5.2. Clinical indications to the exam

The majority of exams were performed for the workup of inflammatory heart disease cardiomyopathies representing overall 55.7% of cases followed by the assessment of myocardial viability and acute infarction (respectively 6.9% and 5.9% of patients).

Most frequent clinical indications were substantially balanced within the first group and included arrhythmogenic right ventricular cardiomyopathy (AVRC; 11.2%) iron overload quantification (9.9%), acute myocarditis (9.8%), hypertrophic and dilated CMPs (9.2% and 8.7% respectively). Detailed results are reported in Table 2.
5.3. Acquisition data

Most of investigations were performed with 1.5T scanners (96.5%), followed by 3T (2.7%) and 1T systems (0.8%) (Table 2) and contrast agent was administered in 84.8% of the exams.

A pharmacologic stress test, using dipyridamole, adenosine or dobutamine, was conducted on 87 cases (3.0%) (Table 3).

Stress imaging mostly consisted in rest/stress perfusion studies with adenosine or dipyridamole (overall 93.0% of exams) whereas dobutamine administration was used in only 7.0% of cases.

List and average amount of contrast agents administered in both rest and stress CMR examinations coupled with pharmacologic stress protocols adopted are reported in Table 3.

Acquisition time ranged between 3 and 150 min with an average scanning duration of 43 ± 13 min per exam; differences in average examination time significantly varied between non-contrast vs. rest vs. stress exams ranging between 35, 44 and 54 min respectively (detailed data are reported in Table 4).

5.4. Safety evaluation

Safety assessment revealed 30 (0.9%) adverse clinical events occurred during or immediately after the procedure (i.e.<60 min), most of which were attributed to patient’s poor clinical conditions prior to the examination (n = 20; 66.6% of the events) (Fig. 1).

Among this first group of patients, events were scored as moderate in two cases due to the occurrence of arrhythmia in acute infarct patients, and mild in the remaining eighteen patients mostly consisting in dyspnea and claustrophobia almost exclusively observed in acute infarct patients (n = 17 plus 1 patient with HCM).

Contrast media-related adverse events were reported in only six cases (0.1%), and scored as mild in five (83.0%) and moderate in one patient presenting with vomit, facial swelling and bronchospasm after contrast administration which required short-term observation.

In the remaining four cases, adverse effects occurred during dipyridamole stress CMR and two were directly related to the drug administration with angina whereas claustrophobia was referred in the remaining two.

No severe reactions or cases of death were reported during or because of the CMR procedure.

5.5. Result of the exam, image quality and impact on patient’s management

Image quality was scored from excellent to good in 82% of cases (fair: 7.1%; poor: 6.3%; insufficient: 2.2%) and no information were available in 96 patients (2.0%).

In 65.0% of cases, CMR was positive and the final diagnosis obtained was considered clinically relevant in 85.4% of the cases providing significant impact on clinical/therapeutic management in 49.4% of patients. Overall, only 6.0% of the diagnoses had no clinical relevance and approximately 1% of exams were not diagnostic (Fig. 2).

The highest prevalence of negative examinations was observed in patients with suspected ARVD (72.0%), followed by those with non-compacted myocardium (45.4%).

The highest impact on patient’s management was reported in stress examinations for CAD (68.0% of the cases), followed by the assessment and quantification of iron overload (64.0% of cases), suspected acute myocarditis (60% of cases), and dilated cardiomyopathy (54.0%), whereas in 61.1% and 52.3% of patients with respectively Tako-tsubo CMP and acute myocardial infarction the examination was found to have no impact on clinical and diagnostic workup.

6. Reporting physicians

Overall 80.1% of the exams were reported by radiologists alone (12.9% with double specialization in radiology/cardiology) and 17.0% by radiologists and cardiologists in consensus whereas, in our series, cardiologists alone represented 2.6% of reporting physicians.
Table 3
Contrast administration protocols in rest and stress exams.

<table>
<thead>
<tr>
<th>Gadolinium chelate</th>
<th>Patients [n]</th>
<th>Min. dose (mmol/kg)</th>
<th>Max. dose (mmol/kg)</th>
<th>Average dose (mmol/kg)</th>
<th>Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gadoteric acid</td>
<td>170</td>
<td>0.1</td>
<td>0.2</td>
<td>0.18</td>
<td>3</td>
</tr>
<tr>
<td>Gadopentetate dimeglumine</td>
<td>619</td>
<td>0.1</td>
<td>0.2</td>
<td>0.16</td>
<td>35</td>
</tr>
<tr>
<td>Gadobenate dimeglumine</td>
<td>776</td>
<td>0.05</td>
<td>0.25</td>
<td>0.16</td>
<td>41</td>
</tr>
<tr>
<td>Gadobutrol</td>
<td>1257</td>
<td>0.05</td>
<td>0.3</td>
<td>0.22</td>
<td>8</td>
</tr>
<tr>
<td>Gadodiamide</td>
<td>4</td>
<td>0.1</td>
<td>0.2</td>
<td>0.17</td>
<td>0</td>
</tr>
<tr>
<td>Gadoteridol</td>
<td>5</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Gadoversetamide</td>
<td>11</td>
<td>Non spec</td>
<td>Non spec</td>
<td>Non spec</td>
<td>0</td>
</tr>
<tr>
<td>Non-specified</td>
<td>534</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 4
CMR protocols and acquisition time.

<table>
<thead>
<tr>
<th>CMR Protocol</th>
<th>N</th>
<th>%</th>
<th>Minimal acquisition time</th>
<th>Maximal acquisition time</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stress no Gadolinium</td>
<td>726</td>
<td>22.0</td>
<td>3′</td>
<td>70′</td>
<td>35′</td>
</tr>
<tr>
<td>No stress + gadolinium</td>
<td>2420</td>
<td>75.0</td>
<td>6′</td>
<td>150′</td>
<td>44′</td>
</tr>
<tr>
<td>Stress + no gadolinum</td>
<td>7</td>
<td>0.3</td>
<td>25′</td>
<td>90′</td>
<td>54′</td>
</tr>
<tr>
<td>Stress + gadolinum</td>
<td>91</td>
<td>3.0</td>
<td>25′</td>
<td>90′</td>
<td>54′</td>
</tr>
<tr>
<td>Total</td>
<td>3244</td>
<td>–</td>
<td>16′</td>
<td>94′</td>
<td>44′</td>
</tr>
</tbody>
</table>

7. Discussion

This Italian CMR survey was designed to evaluate diffusion and geographic distribution of the various national centers performing the exam, verifying technical equipment, protocols adopted, safety profile and spectra of clinical indications.

Besides providing “locally” useful data however, this registry represents a large patient’s database recruited in a relatively short time interval (3376 patients during a six-month period of enrollment) and derived from the experiences of forty different centers, using multivendor equipment and contrast agents and covering variable levels of CMR expertise due to the open-access nature of the study.

A further element of evaluation is the predominant radiological involvement of participating sites characterized by 80.1% of exams read and reported by radiologists (including 12.9% of double specialty physicians) plus 17.0% of cases performed in consensus with cardiologists with relevant differences from the Euro-CMR data in which role of radiologists was limited to only 2.6% of cases with an additional 26.7% of cases read by a combined team of cardiologist and radiologists [3]. This discrepancy can be attributed to a “specialty-oriented” bias in the selection of referring centers related to the different background of groups who initiated and promoted both registries representing respectively the CMR working group of the European Society of Cardiology and the Working Group of the Cardiac Radiology Section of the SIRM. Radiologically “imbalanced” data were also published in 2006 by Levin and coll, who reported a 91% prevalence of exams performed by radiologist in a large Medicare-based patient’s database of 110,743 CMR studies analyzed [1]. An additional general bias of any registry like ours regards the intrinsic impossibility to determine the exact degree of completeness of patient’s enrollment per center with obvious potential and unpredictable impact on prevalence of indications and on results in general.

Fig. 2. Bar chart showing impact of CMR examination on patient’s clinical and therapeutic management for the most frequent indications.
7.1. Technical equipment and acquisition protocols

State of the art of CMR imaging is performed in Italy using 1.5 T magnets in the vast majority of cases (96.5% of exams) whereas use of 3 T scanners was limited in our database to 2.7% of patients.

These results are substantially in line with those of the Euro-CMR (95% of studies performed with 3 T machines) and confirm that both the higher scanners’ costs and technical challenges (field homogeneity reduction with increased susceptibility artifacts and radiofrequency-induced power deposition) associated with high field systems are still perceived as major drawbacks by most centers limiting their diffusion and utilization in the territory only to few research sites regardless significant recent improvements and potential advantages of 3T imaging in CMR [5,10,11].

Most of the examinations were performed with intravenous administration of contrast agents (84.8%), confirming that CMR is a contrast-dependent technique in most of the cases and its ability in tissue characterization is further enhanced by use of gadolinium and late enhancement techniques allowing to characterize myocardial disease with different late enhancement patterns in a large variety of clinical conditions [12–15].

Pharmacological stress was performed in only 3.0% of our patients’ population as compared to the Euro-CMR registry in which perfusion and/or functional stress protocols were used in 34.2% of cases to rule out myocardial ischemia and viability [5]. Stress imaging mostly consisted in rest/stress perfusion studies with adenosine or dipyridamole (overall 93.0% of exams) whereas dobutamine administration was used for the assessment of inducible ischemia in only 7.0% of cases likely as a consequence of the lower safety profile of the drug at higher doses, with major events reported in 3–21% of patients and requiring resuscitation MR-compatible equipment and medications managed by dedicated medical staff [16]. The low prevalence of stress exams in our patient’s population highlights an important feature of present registry, which mainly reports activity, performed in radiological units as compared to the prominent clinical/cardiological background of the EuroCMR. This observation accounts the different attitude of cardiologists toward use of stress imaging for the evaluation of CAD and a probably deeper clinical comprehension of the added value of MR in this clinical setting as compared to echocardiography or SPECT [17]. An additional issue to consider in this regard, concerns the extremely variable experience of the centers involved which might have oriented a different pathology focus in less specialized sites in favor of more manageable and easily approachable indications (see Section 7.2).

The direction to follow is also likely to further educate referral physicians regarding CMR added clinical value in the clinical setting of myocardial ischemia.

7.2. Clinical indications and impact on patient’s management

The majority of exams were performed for the evaluation of inflammatory heart disease cardiomyopathies, representing overall 55.7% of cases as compared to the respectively 6.9% and 5.9% of patients addressed for myocardial viability assessment and acute myocardial infarction (Table 2).

These indications again show a remarkable difference from the recently updated results of the Euro-CMR registry, in which ischemia and suspected CAD surpassed cardiitis/cardioangiopathies (respectively 34.2% vs. 32.2%) with an additional 14.6% of patients examined for myocardial viability assessment [5].

Rather than a single predominant clinical request, there were five substantially balanced most frequent indications in our series, ranging between 11.2% and 8.7% of cases and represented (in order) by ARVC, iron overload quantification, acute myocarditis, hypertrophic and dilated CMPs.

Aortic disease was not included in the list of our exams as we meant to specifically focus on cardiac pathology referring to great vessels only in presence of predominant myocardial involvement (like in congenital heart disease and pulmonary hypertension).

Interestingly, list of indications reported in Table 2 accounts for only 74.9% of all the exams recorded in our registry and highlights that there was a significant 25.1% of studies which were classified as “other indications” or “non-specified clinical request”.

The reason for this result might be either attributable to the lack of clinical information at the moment of CMR examination or more likely simply reflects a high rate of incomplete filling of patient’s electronic forms by referring centers.

ARVC was the first indication of our registry (11.2% of exams), which is partially explainable with the relatively high prevalence of this disease in the Italian territory [18,19] and most likely depends on the unique diagnostic contribution offered by CMR in this cardiomyopathy allowing to identify the various morphological and functional hallmarks of the disease [20–22]. Despite the low incidence of disease, we had an unexpected prevalence of 23.0% positive cases in our patient’s population representing an unlikely false positive rate likely attributable to the trend to over-reading and over-diagnose ARVD in less experienced operators which was previously described by Sen-Chowdhry et al. [23]; this trend may be caused by the difficulty in recognizing and discriminating normal vs. abnormal morphological and functional findings within the thin-walled, trabeculated, complex anatomy of the right ventricle.

Second CMR indication of our database (9.9%) was the evaluation of patients with primary or secondary forms of myocardial siderosis in which use of multiecho gradient echo T2* sequences allows to diagnose and quantify myocardial iron overload in a preclinical stage and to monitor effects of chelation therapy offering important insights for understanding the pathophysiology of iron accumulation and the complex dynamics of its pharmacological clearance [24,25].

The high prevalence of this request in our patient’s cohort also probably depends on the epidemiology of β-thalassemia in Italy, which is endemic in specific areas of the country including major islands (Sicily and Sardinia), the lower Po valley and the regions of Lazio, Puglia and Calabria [26]. Impact of the exam in this clinical setting was regarded among the highest of our patient’s cohort (only following the relatively limited number of stress-exams performed) with a significant influence on patient’s management in 64.0% of the cases which indirectly confirms the importance to routinely (at least on an annual base) evaluate cardiac T2* of all chronically transfused patients [27].

A further common and high-impact indication was the evaluation of patients with suspected acute myocarditis (9.8% of exams), in which CMR addressed a different therapeutic/diagnostic clinical management in 60% of cases in recognition of the high sensitivity of the exam to detect signs of active inflammation represented by edema, capillary leakage and fibrosis/necrosis [16].

Diagnostic workup of dilated and hypertrophic CMPs was also frequently required in our series (respectively 9.2% and 8.7%) with an important contribution acknowledged to the exam (relevant and with impact on management in respectively 54% and 41% of cases) reflecting its role in the differential diagnosis between the various types of dilated and hypertrophic phenotypes of disease and its important prognostic implications [28–30].

7.3. Safety profile

Our patient’s cohort data confirm the high safety profile of CMR examination with overall only 30 (0.9%) adverse mild or moderate clinical events recorded during or immediately after the procedure without occurrence of severe reactions/death.
Most of the events were observed in patients with acute myocardial infarction (17 cases) and were related to patient’s baseline clinical conditions with onset of arrhythmias and/or dyspnea during CMR requiring to end the examination.

Contrast media related adverse effects were reported in only 0.18% (n = 6) of administrations mostly consisting in mild reactions (n = 5) with only one patient presenting a moderate anaphylactoid reaction requiring short-term monitoring before discharge. Our results are completely in line with the recently published data extracted from the Euro-CMR study in which 30 acute adverse reactions (0.17%) occurred in a large cohort of 17,767 doses administered [31]. Similar findings were reported in larger studies analyzing the incidence of gadolinium-related contrast media reactions reporting event rates ranging between 0.04 and 2.2% [32–34].

We could not analyze differences in reaction rates between the various gadolinium-based contrast molecules due to the limited number of events observed in our population although a lower adverse reactions incidence for nonionic gadolinium-based contrast agents has been reported in literature as compared to ionic linear or macrocylic agents [32].

Our study design did also not include patient’s follow-up after contrast administration, thus excluding the possibility to identify late contrast-related adverse reactions such as nephrogenic systemic fibrosis (NSF), which has been however virtually eliminated by preventive measures including screening for the presence of renal dysfunction in all patients requiring gadolinium-enhanced MR evaluation.

Adverse events related to pharmacological-stress were reported in four cases and attributed to drug's collateral effects only in two patients undergoing dyssynchronous stress myocardial perfusion and scored as mild (angor in both cases). The limited number of stress exams performed in our registry limits any safety profile evaluation although both perfusion and functional stress CMR have been reported to be safe, accurate and with minimal side effects in several studies and literature metaanalysis [16,35].

8. Conclusions

Our registry has shown a wide diffusion of cardiac MR-dedicated centers in Italy which are mostly conducted by radiologist.

Relevant differences have emerged in terms of clinical indications between the SIRM and Euro-CMR databases as a result of the different clinical and cultural backgrounds of the groups and sites involved, but also reflecting different diseases epidemiology, with a prevalence of exams addressed for iron-overload assessment and suspected ARVD and a limited number of stress-studies performed in our patient’s cohort. In most cases, diagnostic contribution provided by the examination was regarded as significant and with impact on clinical management.

The limited incidence and low severity of adverse clinical events observed in our registry confirms that CMR is a safe examination with a low rate of acute contrast-related adverse reactions which was similar in our patient’s database to literature data.

Further research focus of CMR registries would probably require systematic clinical follow-up of patient’s enrolled in order to analyze mid- and long-term implications of CMR findings providing wider comprehension of its clinical role in the complex scenario of cardiovascular diseases.

References


[6] Thomas B, Tavares NJ. Do the results of the German pilot phase of the EuroCMR Registry indicate that the chasm has been crossed? Journal of the American College of Cardiology 2010;55(4):412.


