Argentine National Cardiac Magnetic Resonance Imaging Registry (RENAREC)

REGISTRO NACIONAL ARGENTINO DE RESONANCIA CARDIACA (RENAREC)

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ON BEHALF OF THE COUNCIL OF COMPUTED TOMOGRAPHY AND CARDIAC RESONANCE, ARGENTINE SOCIETY OF CARDIOLOGY

BACKGROUND

The usefulness of cardiac magnetic resonance imaging (MRI) has greatly increased in the last years. Different international registries have been published on its use; however, there is no data available from Argentina.

OBJECTIVE

The aim of this study was to evaluate different indications, protocols, safety and therapeutic consequences of cardiac MRI in Argentina.

METHODS

A prospective national registry was designed with collection of demographic data, indications for cardiac MRI, associated complications, diagnoses and therapeutic consequences.

RESULTS

A total of 34 centers from 10 provinces of Argentina (85% private and 59% with inpatient capacity) participated in the study, including 1131 patients (mean age 54±18 years and 61% males). The main indications for cardiac MRI were hypertrophic cardiomyopathy (13.9%), and ventricular arrhythmia (12.3%). In 99.7% of cases, no study complications were reported. The most frequent results of cardiac MRI were: normal (31.2%), non-ischemic cardiomyopathy (14.7%), ischemic-necrotic cardiomyopathy (11.6%) and hypertrophic cardiomyopathy (8.9%). Clinical suspicion was confirmed in 23.6% of cases and cardiac MRI generated an unexpected new diagnosis in 48.7% of cases. The main therapeutic consequences were hospital discharge (31.6%) followed by change in medication (28.1%).

CONCLUSIONS

Cardiac MRI is widely used in Argentina, mainly in private centers with a very low incidence of complications. Cardiomyopathies (hypertrophic and dilated) and ventricular arrhythmia are its main indication, and it provides a new unsuspected diagnosis in almost half of the cases. Further studies are required to assess its clinical and therapeutic impact.

KEY WORDS: Cardiovascular Magnetic Resonance - Therapeutic implications - Cardiomyopathies - Registries - Argentina

RESUMEN

Introducción: La utilidad de la resonancia magnética cardiaca (RMC) ha crecido ampliamente en los últimos años. En los últimos años se han publicado distintos registros internacionales sobre su uso, pero no contamos con este tipo de información en Argentina.

Objetivo: Evaluar indicaciones, protocolos utilizados, seguridad y consecuencias terapéuticas de la RMC en la República Argentina.

Materiales y métodos: Se diseñó un registro prospectivo a nivel nacional con recolección de datos demográficos, indicaciones de RMC, complicaciones asociadas, diagnósticos y consecuencias terapéuticas.

Resultados: Participaron 34 centros de 10 provincias de Argentina (85% centros privados, 59% centros con internación). Se incluyeron 1131 pacientes (edad 54±18 años, 61% varones). Las principales indicaciones para el estudio de RMC fueron la miocardiopatía hipertrófica (13.9%) y la arritmia ventricular (12.3%). El 99.7% de los estudios fueron reportados sin complicaciones. Los resultados más frecuentes de la RMC fueron: normal (31.2%), miocardiopatía no isquémica (14.7%), miocardiopatía isquémico-necrótica (11.6%) y miocardiopatía hipertrófica (8.9%). La sospecha clínica fue confirmada en el 23.6% de los casos y la RMC generó un diagnóstico nuevo no sospechado en el 48.7% de los casos. Las consecuencias terapéuticas más frecuentes fueron el alta hospitalaria (31.6%) seguida del cambio en la medicación (28.1%).

Conclusiones: La RMC es un estudio ampliamente utilizado en Argentina, principalmente en centros privados, con un número muy bajo de complicaciones. Las principales indicaciones son las miocardiopatías (hipertrófica y dilatada), y provee un diagnóstico nuevo no sospechado en casi la mitad de los casos. Se requieren de otros estudios en el futuro para evaluar las implicancias clínicas y terapéuticas.

PALABRAS CLAVE: Resonancia magnética cardiaca - Implicancias terapéuticas - Miocardiopatías - Registros - Argentina

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INTRODUCTION
The usefulness of cardiac magnetic resonance imaging (CMR) when infiltrative cardiomyopathies are suspected (IC) and to identify the ischemic or non-ischemic origin of dilated cardiomyopathies (IIA). It is also considered the gold standard to estimate ventricular volumes and function, and due to its great capacity to characterize the myocardium, it provides essential information about the etiology and prognosis of different cardiomyopathies.

Several international registries published in the last years have reported the different indications, quality and clinical impact of cardiac MRI studies in Europe and the United States, but there is no available data for developing countries.

Knowledge of the current state of cardiac MRI in the different institutions of our country is crucial at the time of developing standardized and safe study protocols, future research projects and resource planning.

Thus, we consider it is necessary to develop a national cardiac MRI registry that provides information about the different protocols used, complications, indications and clinical impact in different centers at a national level. Based on this premise, the Argentine Society of Cardiology implemented the Argentine National Cardiac Magnetic Resonance Imaging Registry (RENAREC).

METHODS
The Argentine Society of Cardiology Computed tomography and Cardiac magnetic resonance council designed a prospective registry inviting all the professionals and centers of the country. Consecutive patients attending any of the participating centers approved by the steering committee, and who gave their consent for the study, were recruited. The study protocol was approved by the ethics committee of the Argentine Society of Cardiology and incorporated in the centralized registry of research projects of the Autonomous City of Buenos Aires.

Data of interest were collected and sent by digital platform to a central analysis core together with the informed consent. Each physician who performed a cardiac MRI was in charge of filling the study forms. Collected variables were: demographic data, study indication, type of magnetic resonance scanner used, sequences utilized, study complications, diagnoses reached and implications on patient treatment.

Statistical analysis
Continuous variables were expressed as mean and standard deviation or median and interquartile range according to their distribution and were compared using Student’s t test or the Wilcoxon test, as appropriate. Categorical variables were expressed as frequencies and percentages and were compared with the chi-square test or Fisher’s exact test, as appropriate. Statistical significance was established for p<0.05.

RESULTS
Between August 2018 and January 2020, a total of 1131 studies from 34 participating centers distributed in 10 Argentine provinces were included in the study. Figure 1 summarizes the geographical distribution of the centers participating in the registry. Fifty percent of centers corresponded to the metropolitan area of Buenos Aires (10 centers in the Autonomous City of Buenos Aires and 7 centers in the Greater Buenos Aires area). In addition, 3 centers were in Tucumán, 2 in Santa Fe, and 1 in Neuquén, Río Negro, Córdoba, Chubut, Corrientes and Catamarca. The centers involved were mostly private (85%) and 74% had only one cardiac magnetic resonance scanner.

In 59% of cases, the institutions were centers with inpatient facilities and the remaining 41% were ambulatory diagnostic centers. The scanners used were 1.5 Tesla in 97.3% of cases, and the rest 3 Tesla.

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**Fig. 1.** Geographic representation of the participating centers. A total of 34 centers from 10 Argentine provinces were included.
Mean age of the included patients was 54±18 years and 61% were male. The most frequent reasons for study indication were hypertrophic cardiomyopathy (13.9%), ventricular arrhythmia (12.3%), dilated cardiomyopathy (9%), left ventricular systolic function impairment (7.3%), congenital heart diseases (5.6%), valve diseases (5.2%) and others (Table 1 and Figure 2).

The cardiac MRI study was completed in 98% of cases, and adverse events were only registered in 0.3% of cases: a patient had dipyridamole-induced dyspnea and two patients presented adverse effects related to gadolinium administration, one with minor allergy (rash) and the other with anaphylactic shock.

In 91.8% of cases, there was good image quality, and only 0.2% of studies were considered unsuitable to be reported. The main reasons for poor image quality were the presence of arrhythmias (54.4%) and breath-hold difficulty (42.3%). Most studies (82%) were performed with an acquisition time between 30-60 minutes and only in 10.1% of cases the acquisition was carried out in more than 60 minutes (Table 2).

The sequences used varied according to the reason for the study; the most frequent were cine-sequences (98.5%) and late gadolinium enhancement (89.3%), and the least frequent were those under pharmacological stress (5%) and tagging sequences (4.4%).

Among the studies performed, 31.2% were reported as normal, and the most prevalent diseases in the main diagnoses were non-ischemic dilated cardiomyopathy (14.7%), ischemic-necrotic cardiomyopathy (11.6%), hypertrophic cardiomyopathy (8.9%) and heart valve diseases (5.8%) (Table 2). The study was useful to confirm the suspected diagnosis in 23.6% of cases, it could not confirm it in 70% of cases and it was unknown in 6.4% of cases due to the ambiguity of the diagnosis in its request. On the other hand, cardiac MRI generated a relevant unsuspected diagnosis in 48.7% of cases. Nevertheless, in 75.7% of these cases there was no information on whether the study caused changes in the therapeutic conduct. In those cases in which this information was available (24.3%, n=275), the most frequent therapeutic implications were hospital discharge (31.6%), changes in the medication (28.1%), a closer follow-up (18.9%) and avoiding an invasive procedure (12.7%).

**DISCUSSION**

This is the first registry showing results of cardiac MRI studies performed in different centers of Argentina representing this practice in our country. Firstly, it highlights the degree of representation at a national level, as different centers from 10 provinces of the country participated in the study. Most were private centers (85%), which could interfere with access to this high-complexity study for those patients without social security coverage who receive care in public health centers. It is also interesting that 41% of participating centers were exclusively dedicated to ambulatory diagnosis. Almost all the scanners used were 1.5 Tesla (97.3%).

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**Table 1.** Baseline population characteristics, types of scanner used and main indications for a cardiac magnetic resonance study. (n=1131)

<table>
<thead>
<tr>
<th>Reason for the study, n (%)</th>
<th>Hypertrophic CMP</th>
<th>Ventricular arrhythmia</th>
<th>Dilated CMP</th>
<th>LV systolic function impairment</th>
<th>Congenital diseases</th>
<th>Heart valve diseases</th>
<th>Search for ischemia</th>
<th>Viability</th>
<th>Myocarditis</th>
<th>Masses/thrombus</th>
<th>Pericardial diseases</th>
<th>MINOCA</th>
<th>Non-compacted CMP</th>
<th>Iron overload</th>
<th>Amyloidosis</th>
<th>Aortic diseases</th>
<th>Acute infarction</th>
<th>Complete LBBB</th>
<th>Arrhythmogenic dysplasia</th>
<th>Chagas</th>
<th>Pulmonary vein anatomy/AF</th>
<th>Collagen disease-associated CMP</th>
<th>Sarcoïdosis</th>
<th>Other</th>
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<tbody>
<tr>
<td>Age (years, SD)</td>
<td>54±18</td>
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<td>Scanner used, n (%)</td>
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<td>1.5 T</td>
<td>157 (13.9)</td>
<td>139 (12.3)</td>
<td>101 (9)</td>
<td>82 (7.3)</td>
<td>63 (5.6)</td>
<td>59 (5.2)</td>
<td>55 (4.9)</td>
<td>53 (4.7)</td>
<td>53 (4.7)</td>
<td>39 (3.5)</td>
<td>39 (3.5)</td>
<td>34 (3)</td>
<td>31 (2.8)</td>
<td>26 (2.3)</td>
<td>23 (2)</td>
<td>23 (2)</td>
<td>16 (1.4)</td>
<td>13 (1.2)</td>
<td>9 (0.8)</td>
<td>6 (0.5)</td>
<td>6 (0.5)</td>
<td>4 (0.4)</td>
<td>1 (0.1)</td>
<td>90 (8)</td>
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<td>3 T</td>
<td>31 (2.7)</td>
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bias, as it was a study launched and carried out by the Argentine Society of Cardiology.

The main reasons for requesting a cardiac MRI were cardiomyopathies and ventricular arrhythmia, and the search for ischemia (4.9%) by cardiac MRI with stress and perfusion technique was infrequent. This was the main difference when comparing these findings with other international registries, as the search for ischemia was the first indication for cardiac MRI in the EuroCMR registry (n=27,781) and

**Fig. 2.** Main indications for the cardiac MRI study.

**Fig. 3.** Comparison of cardiac MRI indications between RENAREC and EuroCMR and SCMR registries (5,6)

CMP: Cardiomyopathy, MINOCA: Myocardial infarction with non-obstructive coronary arteries, LV: Left ventricular.
the second in the Global SCMR registry (n=62,456) (5,6) (Figure 3). In the latest guidelines on chest pain management, stress cardiac MRI looking for ischemia is on the same level of recommendation than stress echocardiogram, single photon emission computed tomography (SPECT) and positron emission tomography (PET) for patients at intermediate ischemic risk and without known coronary lesions in the acute condition (recommendation IB), and for patients with intermediate-high risk chronic pain without known coronary lesions, both for the diagnosis of coronary heart disease as for stratification of major cardiovascular events risk (recommendation IB). (7) Considering that CMR with dobutamine has been shown to have greater diagnostic accuracy than dobutamine stress echocardiography, and to be a safe procedure, we believe that the costs and the impossibility of performing stress with exercise are the main limitations to its application. (9-12) This method to look out for ischemia is expected to grow in the next years.

The complications associated with the study of cardiac MRI were infrequent (0.3%) and only one patient (0.08%) presented a severe adverse effect associated with gadolinium administration. Although in our study the type of gadolinium used was not available, these findings are in agreement with the safety data of contrast agents with gadolinium observed in large international registries. (13-18)

In most cases, physicians performing the study interpreted image quality as good (91.8%) and only 0.2% could not report the study due to poor acquisition quality; two main causes for this difficulty were marked presence of arrhythmia and breath-hold inability. New sequence technologies and protocols should lead to solve these problems. On the other hand, most registry studies demanded 30-60-minute acquisition time. The current cardiac MRI acquisition protocols’ guideline published a few months after this registry ended, includes fast acquisition protocols for follow-up in certain clinical scenarios as hypertensive or hypertrophic cardiomyopathy, viability and cardiotoxicity. (19,20) The incorporation of these protocols to clinical practice will certainly decrease the acquisition times in the near future.

Cardiac MRI indicated a new unsuspected diagnosis in almost half of the studies (48.7%). Since a large number of studies was performed in ambulatory diagnostic centers, it is logical that in more than 75% of cases we have no information on the clinical impact of the cardiac MRI result. However, it is very interesting to highlight the data of those studies in which this information was acquired (24.3%, n=275). The main therapeutic changes brought up by cardiac MRI were hospital discharge in 31.6% of cases, a change in medication in 28.1% and a closer follow-up in 18.9%. It should also be pointed out that cardiac MRI avoided an invasive procedure in 12.7% of cases. These data are similar to the EuroCMR Registry, mainly regarding the change in medication observed in that registry (25%). One of the main differences encountered was that cardiac MRI led to an invasive procedure in 16% of cases in the European registry, while it only did so in 4% of our studies, a difference that is probably explained by the high cardiac MRI indication searching for ischemia in Europe. (6,7)

### Table 2. Adverse effects, quality and main diagnoses of cardiac MRI (n=1131)

<table>
<thead>
<tr>
<th>Completed the study, n (%)</th>
<th>No</th>
<th>Yes</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>23 (2)</td>
<td>1108 (98)</td>
</tr>
<tr>
<td>Adverse effects n (%)</td>
<td>Not present</td>
<td>1016 (89.8)</td>
</tr>
<tr>
<td>Minor allergy (Skin rash)</td>
<td>1 (0.1)</td>
<td></td>
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<tr>
<td>Mayor allergy (Shock)</td>
<td>1 (0.1)</td>
<td></td>
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<tr>
<td>Dipyridamole-induced dyspnea</td>
<td>1 (0.1)</td>
<td></td>
</tr>
<tr>
<td>Does not apply (study without contrast)</td>
<td>112 (9.9)</td>
<td></td>
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<tr>
<td>Quality of the study, n (%)</td>
<td>Good</td>
<td>1038 (91.8)</td>
</tr>
<tr>
<td>Fair</td>
<td>91 (8)</td>
<td></td>
</tr>
<tr>
<td>Not reportable</td>
<td>2 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Reason for bad quality, n (%)</td>
<td>Arrhythmia</td>
<td>49/90 (54.4)</td>
</tr>
<tr>
<td>Breath-hold inability</td>
<td>38/90 (42.3)</td>
<td></td>
</tr>
<tr>
<td>Poor LGE inversion</td>
<td>2/90 (2.2)</td>
<td></td>
</tr>
<tr>
<td>Metallic artifact</td>
<td>1/90 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Cardiac MRI diagnosis, n (%)</td>
<td>Normal study</td>
<td>349 (31.2)</td>
</tr>
<tr>
<td>Non ischemic-necrotic cardiomyopathy</td>
<td>167 (14.7)</td>
<td></td>
</tr>
<tr>
<td>Ischemic-necrotic cardiomyopathy</td>
<td>130 (11.6)</td>
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<tr>
<td>Hypertrophic cardiomyopathy</td>
<td>100 (8.9)</td>
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<tr>
<td>Heart valve disease</td>
<td>66 (5.8)</td>
<td></td>
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<tr>
<td>Congenital diseases</td>
<td>53 (4.7)</td>
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<tr>
<td>Myocarditis sequelae</td>
<td>46 (4.1)</td>
<td></td>
</tr>
<tr>
<td>Pericardial disease</td>
<td>38 (3.4)</td>
<td></td>
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<tr>
<td>Aortic disease</td>
<td>32 (2.9)</td>
<td></td>
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<tr>
<td>Amyloidosis</td>
<td>21 (1.9)</td>
<td></td>
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<tr>
<td>Acute myocarditis</td>
<td>19 (1.6)</td>
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<tr>
<td>Non- compacted cardiomyopathy</td>
<td>17 (1.5)</td>
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<tr>
<td>Primary tumor</td>
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<tr>
<td>Arrhythmogenic dysplasia</td>
<td>8 (0.7)</td>
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<tr>
<td>LV thrombus</td>
<td>7 (0.6)</td>
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<tr>
<td>Other</td>
<td>48 (5.1)</td>
<td></td>
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</tbody>
</table>

LGE: Late gadolinium enhancement; MRI: Magnetic resonance imaging, LV: Left ventricular.
CONCLUSIONS
Cardiac MRI is a national widespread study in Argentina, mainly in private healthcare centers. It is a safe practice with a very low number of complications. Its main indication is the study of cardiomyopathies and ventricular arrhythmia, and it provides a new unsuspected diagnosis in nearly half of cases. Future studies are required to evaluate the clinical and therapeutic implications of this study.

Conflicts of interest
None declared.

(See authors' conflict of interests forms on the web/Additional material.)

Financing
None.

REFERENCES

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