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# Cardiac magnetic resonance imaging during the COVID-19 pandemic: A southern Italian single-center experience

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## HIGHLIGHTS

- The number of CMR studies significantly decreased during COVID-19 pandemic.
- Proportion of abnormal CMR results was similar between two time-interval categories.
- Missed or delayed diagnoses may have occurred during the lockdown.

## ARTICLE INFO

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## ABSTRACT

*Purpose:* We aimed to assess the impact of COVID-19 pandemic on cardiac magnetic resonance (CMR) imaging studies performed during the lockdown imposed by the Italian Government from March 2020 to May 2020.
*Materials and method:* We reviewed the number and the findings of CMR scans performed during the COVID-19 pandemic between March and May 2020 at University of Naples Federico II. The number and the findings of CMR studies acquired in the corresponding months of 2017, 2018 and 2019 were also assessed for direct comparison.
*Results:* A total of 117 CMR studies was considered, including the procedures performed during the pandemic (n = 18) and those performed in the corresponding months of the prior 3 years (n = 99). The number of CMR studies performed during the COVID-19 pandemic was significantly ($P < .01$) lower compared to the mean number (n = 33) of the procedures performed in the corresponding months of 2017−2019. The percentage of abnormal CMR studies was similar ($P = 0.73$) during the pandemic (67 %) compared to that found in the corresponding months of 2017−2019 (70 %) suggesting that many abnormal tests were missed due to the lockdown.
*Conclusion:* The number of CMR studies was significantly reduced during the COVID-19 pandemic compared to the corresponding period of the previous three years. The lack of difference in the prevalence of abnormal CMR studies between the two study time intervals strongly suggests that many patients with potentially abnormal imaging test have been missed during the pandemic.

## 1. Introduction

COVID-19 pandemic emergency has put a strain on worldwide healthcare systems requesting a sudden adjustment of the medical routine to extraordinary needs [1–4]. The onset and progression of pandemic significantly differed between countries, with the most imposing strict social limitations. The severe acute respiratory syndrome coronavirus-2 is responsible for COVID-19, being transmitted by droplets from person to person [5,6]. In order to reduce the risk of patient-to-patient, patient-to-health-workers and vice-versa contagion and to optimize hospital resources, all patients scheduled for diagnostic imaging procedures with non-severe symptoms or not candidate to invasive or surgical treatments have been postponed [7,8]. Nevertheless, the postponement of "non urgent" procedures, could have

*Abbreviations:* CMR, cardiac magnetic resonance; STIR, short tau inversion recovery; LGE, late gadolinium enhancement.

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determined substantial consequences on patients' outcome. Cardiac magnetic resonance (CMR) is established in clinical practice for the diagnosis and management of several cardiovascular pathologies such as coronary artery disease, primitive cardiomyopathies, as well as for myocardial tissue characterization and myocarditis-related injuries assessment [9]. In particular, myocarditis may be a clinical manifestation of COVID-19 making CMR a potential tool directly involved in the COVID-19 diagnostic workflow [10–12].

Italian Government has been called upon to take restrictive measures against COVID-19 spread a few weeks in advance as compared to other Western World countries [13]. Therefore, if on one hand Italy paved the way, on the other, the transition time window between the pre-COVID-19 and the COVID-19 era of healthcare management has been exceedingly restricted. It should be taken into account that COVID-19 tsunami hit Italian regions with different vehemence. Southern Italy hospitals, mostly spared by pandemic first wave, were more conditioned by containment measures against the virus. Taken together, these factors make Southern Italy a unique example of the effect of sudden and unexpected containment measures on non-COVID-19 medical routine.

Thus, the aim of this study was to assess the impact of COVID-19 pandemic on CMR routine workflow in a Southern Italy imaging unit, during the lockdown imposed by the Italian Government from March 2020 to May 2020 [14].

## 2. Material and methods

### 2.1. Patients

We retrospectively reviewed CMR studies acquired between March 2020 to May 2020. The number and the findings of CMR exams acquired in the corresponding months of 2017, 2018 and 2019 were also assessed for direct comparison. All patients admitted to the CMR unit demonstrated laboratory tests negative for COVID-19 infection. This study complies with the declaration of Helsinki. The review committee of our institution approved the study.

### 2.2. CMR

CMR was performed by using a superconducting system 1.5 T scanner (Gyroscan Intera, Philips Medical System, Best, The Netherlands) with a maximum gradient capability of 30 m T/m and maximum slew rate of 150 T/m/s. CMR acquisition was triggered by ECG and included: cine 2D balanced turbo field-echo multiphase-multislice in short axis, vertical long axis, and horizontal long axis, T2-weighted-short tau inversion recovery (STIR) sequences and 3D T1-delayed enhancement sequences. Left ventricular volumes, mass, ejection fraction, wall thickness and delayed enhancement patterns were analyzed on a dedicated workstation, as previously described [15]. CMR results were defined abnormal when clinical indications or suspicions were confirmed.

### 2.3. Statistical analysis

Continuous data are expressed as mean ± standard deviation and categorical data as percentage. Student *t*-test and $\chi^2$ test, were used to compare the differences in continuous and categorical variables, respectively. Fisher's exact test was used to compare patients undergoing CMR to evaluate myocarditis between the two time-range periods. Poisson test was used to compare the number of CMR test performed during the lockdown and those during the corresponding time interval of the previous three years. Two-tailed *P* values <.05 were considered significant. Statistical analysis was performed with R software version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria).

## 3. Results

A total of 117 CMR studies were considered, including tests performed during the pandemic between March and May 2020 ($n = 18$) and those performed in the corresponding months of the prior 3 years (2017−2019) ($n = 99$). In particular, clinical indications to CMR study were suspected myocarditis/pericarditis, coronary artery disease suspected or known, evaluation of cardiac involvement of storage disorders, primitive cardiomyopathies, arrhythmias, cardiac masses. The number of CMR studies performed during the pandemic was significantly ($P < .01$) lower compared to the mean number of procedures in the corresponding months of 2017−2019 (Fig. 1). However, the percentage of abnormal CMR studies was similar ($P = 0.73$) during the pandemic (67 %) compared to that found in the corresponding months of 2017−2019 (70 %) (Fig. 2). Of note, considering the mean number of abnormal CMR studies observed during the previous three-years period ($n = 23$) and the pandemic ($n = 12$), 48 % of abnormal tests may have been missed during to the lockdown.

Clinical characteristics of overall population during COVID-19 pandemic and the corresponding 2017−2019 months are described in Table 1. The mean age and the mean body surface area of patients referred to CMR was not different between the two time-ranges, while the percentage of male patients was higher during COVID-19 outbreak compared to the previous time-range. Considering the CMR findings (Table 2), LV ejection fraction values, the prevalence of LV hypertrophy, late gadolinium enhancement (LGE) were comparable between the two time-range categories. Conversely, the percentage of patients with presence of myocardial edema detected by STIR sequences was significantly higher during the COVID-19 pandemic months ($P < .05$).

The percentage of patients referred to CMR to evaluate myocarditis, which may be a clinical manifestation of COVID-19, did not differ between the two time-range categories (Fig. 3). Similarly, the percentage of patients showing myocarditis at CMR was comparable during pandemic (4%) and the previous three years (5%) ($P = $ NS).

## 4. Discussion

Italy has been among the most impacted countries by COVID-19 outbreak, with a high number of deaths and a high case fatality rate. The Italian Government implemented extraordinary restriction measures to limit viral transmission by COVID-19, with the aim to reduce the likelihood that people came into contact with infected subjects [14]. As a consequence, inpatient and outpatient services have been significantly reduced in preparation for a possible increase of COVID-19-related admissions and also to reduce the possibility of contacts and disease transmission.

The results of our study demonstrate that during the lockdown the number of CMR studies was significantly reduced as compared to the corresponding months of the previous three years. These findings are in agreement with European and North American Scientific Societies strategies, suggesting limiting cardio-vascular diagnostic imaging to urgent or semi-urgent patients during the COVID-19 outbreak to reduce the shortage of healthcare resources [3,16].

A relevant information from this study is that, taking into the account the mean number of abnormal CMR studies observed at our department during the previous three-years period and during the pandemic, 48 % of abnormal tests may have been missed during the lockdown. Bath et al. [17] explored trends in hospitalizations for acute cardiovascular conditions before and during the first wave of COVID-19 pandemic in a large, tertiary care institution, observing a strong decline in acute cardiovascular admission and a shortening in hospitalization length. Similarly, Pang et al. [18], in a recent paper stated that their center experienced a reduction in the number of echocardiograms, stress echo, nuclear medicine procedures, calcium score, coronary computed tomography angiography and CMR during pandemic compared to the corresponding months of 2019. A number of studies also highlighted the

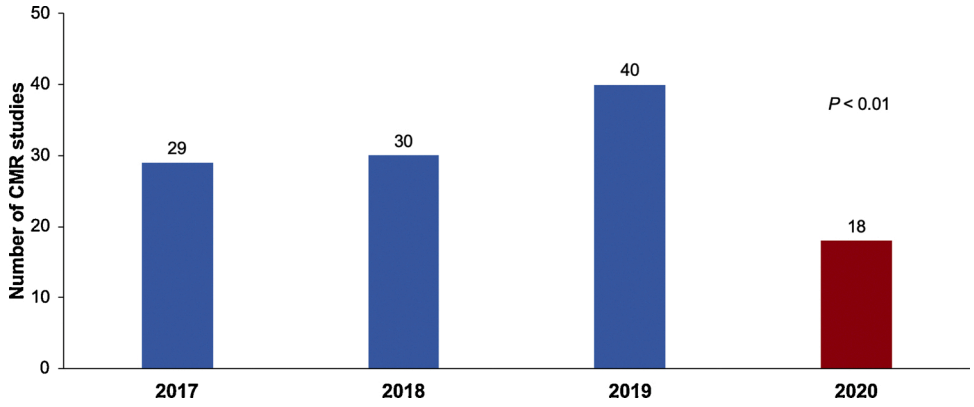


**Fig. 1.** Number of CMR procedures performed during COVID-19 pandemic and during corresponding months of 2017, 2018 and 2019.

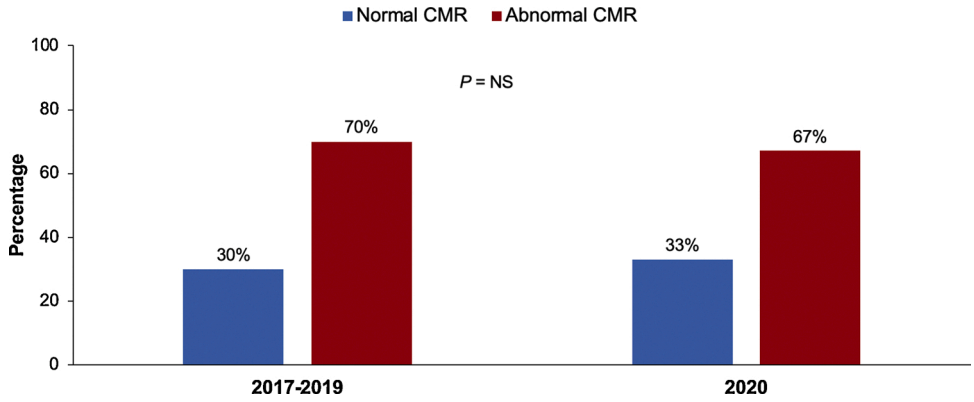


**Fig. 2.** Prevalence of normal and abnormal CMR tests across COVID-19 pandemic and corresponding months of 2017-2019.

**Table 1**
Characteristics of patients undergoing a CMR study during COVID-19 emergency and during 2017-2019 three-year's corresponding months.

| | 2020 ($n = 18$) | 2017–2019 ($n = 99$) | *P* value |
|---|---|---|---|
| Age (years) | 53.4 ± 13.4 | 53.1 ± 16.1 | NS |
| Male gender, *n* (%) | 16 (89) | 60 (61) | <.05 |
| Body surface area ($m^2$) | 1.89 ± 0.23 | 1.88 ± 0.24 | NS |

Values are expressed as mean ± standard deviation or as number (percentage) of subjects.

**Table 2**
CMR study results during COVID-19 emergency and during 2017-2019 three-year's corresponding months.

| | 2020 ($n = 18$) | 2017–2019 ($n = 99$) | *P* value |
|---|---|---|---|
| LGE +, *n* (%) | 10 (56) | 50 (51) | NS |
| STIR +, *n* (%) | 5 (28) | 8 (8) | <.05 |
| Left ventricular hypertrophy, *n* (%) | 4 (22) | 36 (36) | NS |
| Left ventricular ejection fraction (%) | 48 ± 14 | 53 ± 15 | NS |

Values are expressed as mean ± standard deviation or as number (percentage) of subjects. LGE, late gadolinium enhancement; STIR, short tau inversion recovery.

concern about consequences of delayed and deferred tests on cardiovascular conditions worsening due to pandemic [19,20].

In our series, no patient was affected by COVID-19. Moreover, during the pandemic the proportion of patients referred to CMR to evaluate myocarditis, which may be a clinical manifestation of COVID-19 [21,22] was not different as compared to the previous three years corresponding months. It is well known that viral infection can be one of the most important causes of myocarditis, especially related to influenza and parvovirus B-19 infection [23]; however, less is known about the cardiac involvement as a complication of COVID-19 [24,25].

It should also be considered the different spread and impact of COVID-19 in Italy that claimed approximately 34 thousand lives since it entered the Country between the end of January and the beginning of February 2020, with a mortality rate that reached 14 percent, significantly higher than that registered in other countries. Since the first case was officially detected at the end of January in Italy, COVID-19 has been spreading fast and on June 29th, 2020, the total number of cases reported by the authorities reached 240.436. In particular, the North of the Country was mostly hit and the region with the highest number of cases was Lombardia, which registered 93.839 cases as reported by Civil Protection Department of Italian Ministry of Health. The neighboring regions of Piemonte, and Emilia-Romagna followed in the list. Conversely, in the Southern part of Italy the fatality rate was significantly lower; in particular, as of June 29th of 2020, the total number of cases in the region of Campania, the most populated region of the South, with a population of around 5.802.000 people, was 4.666, with a total number of deaths of 431 versus 16.640 of Lombardia and an overall fatality rate of 9% versus 18 %.

Among the lessons learned from the COVID-19 outbreak, national health systems need to be prepared for dealing with large volume of COVID-19 patients, many of whom would need acute intensive care. Furthermore, the public hospital system is called to avoid a decrease of standard diagnostic procedures rate. This necessity implies two main goals to be guaranteed. First, countries lockdown should not affect clinical routine. This novel challenge requires the ability of hospital facilities to carry on daily medical practice and, at the same time, to face any kind of emergency ensuring standardized and independent tracks.

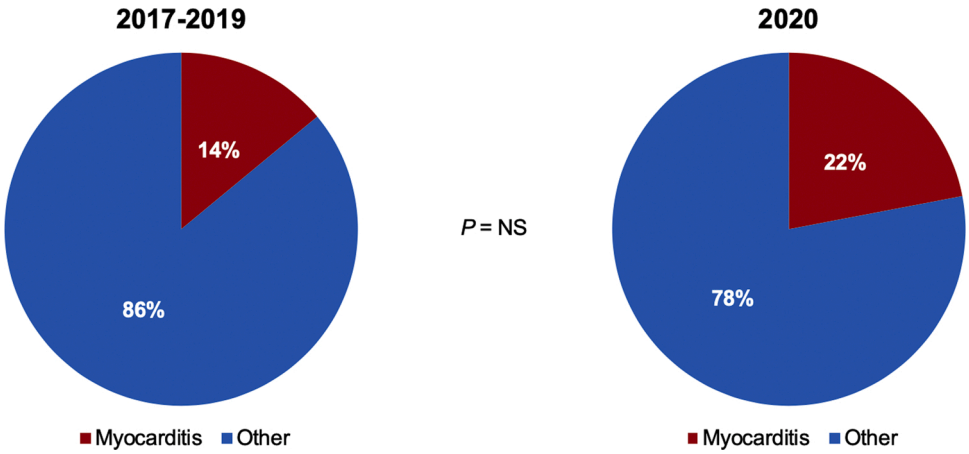


**Fig. 3.** Prevalence of myocarditis evaluation tests across COVID-19 pandemic and corresponding months of 2017-2019, as compared to CMR tests performed to evaluate different clinical questions.

Thus, there is the need to provide rapid triage and management of patients, permanent and dedicated healthcare personnel, as well as facilities, beside routine protocols so that medical resources may be adequate, obviating overload issues. In addition, patients have to trust into national healthcare system as a safe place to be cured protected from contagion.

## 5. Study limitations

This paper presents some limitations that should be addressed. First of all, its retrospective nature. The small sample size represents another limitation. However, it should be taken into account that this study refers to a single-center experience. Moreover, this paper only refers to first wave pandemic. Further investigations should evaluate data regarding virus outbreak during the subsequent wave of pandemic.

## 6. Conclusion

The number of CMR studies performed during COVID-19 outbreak was significantly lower compared to the corresponding months of the previous three-year period. Nevertheless, the proportion of abnormal CMR results did not differ between the two time-interval categories, suggesting potential missed or delayed diagnoses.

## Credit_Author_Statement

AP,CN designed the study and drafted the manuscript; AP, CN, RA collected data; MP, RM performed statistical analysis; AC, MI overviewed the work, read and approved the final manuscript.

## Ethics approval

This study complies with the declaration of Helsinki. The review committee of our institution approved the study.

## Consent for publication

The authors have approved the final article.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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