Original Research Article

Myocarditis during SARS-CoV-2 infection: about 15 cases

Abstract

COVID-19 is a global health problem responsible for significant morbidity and mortality and a major socioeconomic impact. While the major manifestation is respirator with a risk of acute respiratory distress syndrome, several extrapulmonary aspects, particularly cardiovascular, have emerged over time.

The aim of our work is to study the clinical, biological, radiological, therapeutic, and evolutionary characteristics of acute myocarditis associated with SARS-CoV-2 infection in comparison to data from the literature.

This is a prospective cohort study conducted at the IbnSina University Hospital in Rabat over a period of 9 months (from January 1, 2021, to September 30, 2021) and included patients hospitalized in different departments managing COVID-19 and diagnosed with acute myocarditis confirmed by cardiac MRI.

Fifteen patients were included during the study period. The average age of patients was 40 years old with a slight male predominance (sex ratio M/F-1.14). The average time between the onset of COVID-19 infection and the appearance of myocarditis symptoms was 17 days. The symptoms were mainly dominated by chest pain (40% of cases), unexplained cardiogenic shock (40% of cases), and palpitations (20% of cases). ECG revealed diffuse repolarization abnormalities in more than half of the cases (53%) and supraventricular tachycardia (27%). The inflammatory markers were significantly disturbed (CRP = 102 +/-47.30 mg/L and ferritin - 510 +/-336.45 ng/mL). Troponin I was elevated with myocarditis kinetics in all patients. Cardiac MRI showed T2 hypersignal corresponding to edema with early and late subepicardial enhancement, mainly located at the level of the left ventricular lateral wall.

The evolution was marked by the occurrence of death in 5 patients (33.33%) in the days following hospitalization for cardiogenic shock and dilated cardiomyopathy in only one case (6.67%). It was favourable for the rest of the patients (60%).

Keywords: Myocarditis, SARS-CoV-2, COVID-19, Anti-COVID treatment, Anti-COVID vaccination

I. INTRODUCTION

Acute myocarditis presents a diagnostic challenge for clinicians, given its clinical polymorphism, differential diagnoses, and estimated annual incidence of 10 to 100 cases per 100,000 inhabitants [1-2].

Nevertheless, its impact on morbidity and mortality is significant. Acute myocarditis is responsible for 6% to 44% of sudden unexpected deaths in young populations, 14% to 32% of rhythm and conduction disorders, and 12% to 46% of non-ischemic dilated cardiomyopathies [3-4].

Numerous and diverse etiologies of myocarditis are dominated by infectious causes, with viral pathogens being the most prevalent [5].

Since the beginning of 2020, the world has been ravaged by the 2019 Coronavirus pandemic. It has been responsible for more than 470 million confirmed cases and more than six million deaths, mostly due to pulmonary involvement via acute respiratory distress syndrome.

Other extra-pulmonary pathological aspects of COVID-19 have been revealed as the global understanding of the pathogenic agent progressed. The universality and accumulation of reports indicating the occurrence of myocarditis following SARS-CoV-2 infection, in the absence of any other diagnostic element that could explain myocardial damage, provide strong causality, although the pathogenesis of this condition is still poorly understood.

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The objective of our study is to investigate the relationship between myocarditis and concomitant SARS-CoV-2 infection, as well as the clinical, paraclinical, prognostic, and therapeutic characteristics of this condition.

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II. MATERIALS AND METHODS

A. Study Objective

The main objective of our work is to study the clinical, paraclinical, therapeutic, and evolutionary characteristics of acute myocarditis during SARS-CoV2 infection.

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B. Study Population

The study population is represented by all patients who meet the inclusion criteria and are hospitalized in the different departments of IbnSina Hospital in Rabat, taking care of COVID-19, over a period of 9 months from January 1, 2021, to September 30, 2021.

1. Inclusion Criteria:

• Individuals aged between 15 and 45 years for males and 55 years for females.
• SARS-Cov-2 infection is confirmed by RT-PCR.

• The diagnosis of myocarditis is confirmed in accordance with the international consensus of learned societies.

2. Exclusion Criteria:

• The presence of a congenital or acquired cardiovascular disease history that may cause or contribute to myocardial involvement.
• The presence of a cardiovascular risk factor.
• The presence of a known pathology as a cause of myocarditis.
• Incomplete or non-exploitable records.

C. Methodology

This is a prospective longitudinal cohort study on the study population for a period of nine months. All data was collected on an exploitation sheet containing anamnestic, clinical, biological, radiological, therapeutic, and evolutionary elements during the entire hospitalization period, and then follow-up in consultation after discharge at 3 months, 6 months, and 1 year.

D. Data Analysis and Statistical

Methods Statistical data entry was carried out using Excel Office 365 software, then analyzed using Epi-Info version 7.1.5 software (March 19, 2015).

III. RESULTS

A. Socio-demographic data:

During the nine-month period, 15 patients were included in the study. The mean age was 37 ± 10 years, with a median age of 40 years and extremes ranging from 17 to 52 years. 53.3% of the patients were male and 46.7% were female, resulting in a sex ratio of 1.17.

B. Clinical data:

1. Initial clinical severity of COVID-19:

Respiratory-wise, 47% of patients had correct oxygen saturation in ambient air, while 53% required respiratory support. Thus, 20% of our patients were on oxygen glasses, 13% on High Concentration Mask (HCM), and 20% were undergoing non-invasive ventilation sessions.

On the scanographic level, two-thirds of our patients (67%) had tissue damage classified as CORADS-5.

2. Time between COVID-19 diagnosis and onset of suggestive symptoms of acute myocarditis:

In our study, the time between the date of confirmation of SARS-CoV-2 infection and the onset of suggestive symptoms of myocardial involvement ranged from 5 to 25 days, with an average delay of 17 days.

3. Initial clinical presentation

The clinical symptoms were dominated by three presentations: Chest pain, infarctoid or pericarditic, was found in 40% of cases, 40% presented an unexplained cardiogenic shock, and 20% reported palpitations.

C. Paraclinical data

1. ECG abnormalities

All our patients presented ECG abnormalities at the time of myocarditis diagnosis. These were mainly ventricular repolarization disorders (53% of cases). 62% had diffuse ST-segment elevation and 38% had T-wave abnormalities.

Supraventricular tachycardia was found in 27% of cases, diffuse microvoltage in 13% of cases, and ventricular extrasystoles in one patient.

2. Biological characteristics

Inflammatory markers were disturbed in all patients with a mean CRP value of 125 mg/L and a ferritin level of 508 ng/mL. (Table 1)

Biological characteristic	Average value per unit corresponding ± ET
K+	4,2 +/-0,47
RA	24 +/- 2,98
Urée	0,39 +/-0,24
Créatinine	9,85 +/- 2,69
Glycémie	0,98 +/- 0,11
Protides	65 +/- 8,05
CRP	**125 +/- 89,90**
Ferritine	**508 +/- 236,58**
Hémoglobine	14 +/- 1,36
Globules blancs	7121 +/- 1745
PNN	4350 +/- 1171
Plaquette	203500 +/-76652

Table 1: Summary table of the biological assessment of our patients.

3. Evolution of cardiac biomarkers

High levels of Troponin I US were found at the time of diagnosis in all cases. They ranged from 0.15 ng/mL to 10.4 ng/mL with a median of 2.47 ng/mL (reference value < 0.040 ng/mL). The kinetics of troponin showed a rapid regression and normalization by the 5th day. (Table 2)

Patients	Baseline Troponin (ng/mL)	D1Troponin (ng/mL)	D2Troponin (ng/mL)	D3Troponin (ng/mL)	D4Troponin (ng/mL)	D5Troponin (ng/mL)
PI	0,005	10,4	2,463	0,71	0,121	0,041
P2	0,02	1,519	0,654	0,21	0,055	0,009
P3	0,01	0,891	0,351	0,092	0,038	0,007
P4	0,01	0,783	0,066	0,023	0,011	0,004
P5	0,01	0,76	0,251	0,05	0,018	0,002
P6	0,008	1,776	0,678	0,101	0,043	0,01
P7	0,008	0,446	0,104	0,015	0,01	0,008
P8	0,035	0,162	0,06	0,033	0,01	0,004
P9	0,01	6,619	1,05	0,08	0,042	0,036
P10	0,033	0,15	0,06	0,01	0,01	0,01
P11	0,01	0,469	0,152	0,085	0,026	0,01
P12	0,02	1,48	0,523	0,062	0,015	0,01
P13	0,025	4,01	1,756	0,811	0,04	0,022
P14	0,008	6,68	2,255	0,761	0,08	0,04
P15	0,033	0,896	0,122	0,04	0,016	0,008
Median	0,02	0,896	0,351	0,080	0,035	0,008

Table 2: Kinetics of troponin levels in our patients.

4. Transthoracic echocardiography

All our patients underwent a transthoracic echocardiography. It showed global hypokinesia with impaired ejection fraction in 4 patients (26.67%), minimal pericardial effusion in three patients (20%), ventricular dilation (6.67%) in one case, and septal hypertrophy (6.67%) in one case. The transthoracic echocardiography was normal in 6 patients (40%).

5. Cardiac MRI

Cardiac MRI was performed in 8 patients, accounting for 53.33% of cases. It revealed the presence of non-ischemic subepicardial late gadolinium enhancement in all these patients, T2 hyperintensity in five patients (33.33%), and an increase in extracellular volume on TI in four patients (26.26%). Cardiac MRI could not be performed in seven patients, six of whom were in cardiogenic shock and one patient under continuous non-invasive ventilation.

Cavity measurements and systolic and diastolic ventricular functions of our patients were normal with good segmental kinetics and preserved intrinsic contractility. Pericardial effusion was present in two patients at the time of MRI.

D. Treatment, follow-up, and outcome

1. Modality and duration of follow-up

All our patients were hospitalized. After discharge, follow-up was carried out through scheduled consultations at the consultation center at 3 months, 6 months, and 1 year.

2. Treatment

The management of patients was based on symptomatic treatment, including titration oxygen therapy, vitamin therapy combining vitamin C and vitamin D, zinc, injectable glucocorticoids, antibiotic therapy in case of bacterial superinfection, anticoagulation, and adequate hydration.

Aspirin and colchicine were used in forms of perimyocarditis, while Tocilizumab and Anakinra were administered in patients with elevated IL-6 levels. No patient received antivirals. The use of antiarrhythmics, particularly beta-blockers, was initiated in some supraventricular tachycardias.

3. Outcome

The average length of stay was 6 days with extremes ranging from 2 to 30 days. The overall mortality rate was 33.33% (5 cases) related to cardiogenic shock referred to fulminant myocarditis.

After one year, only one patient developed dilated cardiomyopathy (CMD) with an ejection fraction of 30%. The other patients had a satisfactory clinical and paraclinical outcome.

IV. DISCUSSION

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A. Myocarditis during SARS-CoV-2 infection:

Cardiac involvement during COVID-19 and its implication in the worsening of prognosis were suspected from the early months of the pandemic. Myocardial injury defined by a significant elevation of myocytarylysismarkers [6] was suggested by Chinese authors from January 2020

In their study of 671 cases of COVID-19. Shi et al. found a rate of 15.8% of patients presenting concomitant myocardial injury, which was responsible for the death of 30.6% of cases. This study also highlighted the remarkable disruption of inflammatory markers in these patients, thus suggesting a probable link between a disproportionate inflammatory response and myocardial injury [7].

Guo et al. reported a rate of 27.8% of concomitant myocardial injury among hospitalized patients for the management of COVID-19 (52 cases out of a total of 187) with a six-fold higher mortality rate compared to other patients whose troponin value was normal (59.6% vs 8.9%) [8].

Other studies estimated this rate between 7.2% to 22.2% of all hospitalized patients for SARS-CoV-2 pneumonia and those admitted to the ICU, respectively [9,10].

Although the first studies highlighted the presence of myocardial injury and suggested it as a prognostic factor, they were hesitant about the nature or etiopathogenic mechanisms, given the frequent presence of cardiovascular comorbidities that could attribute or explain myocardial injury.

The diagnosis of myocarditis as the cause of this myocardial injury was first suggested in the context of fulminant myocarditis. Hu et al. reported the case of a 37-year-old man presenting with unexplained cardiogenic shock concomitant to COVID-19 pneumonia.The patient's condition improved with symptomatic treatment, and the diagnosis of fulminant myocarditis due to SARS-CoV-2 was retained [11]. Three months later, the first confirmed myocarditis due to SARS-CoV-2 was diagnosed in Italy in a 60-year-old woman with unexpected cardiogenic shock.

Globally, cardiac MRI was limited for COVID-19 positive patients in whom myocarditis was highly likely, which could be explained by the risk of exposure of radiological equipment and personnel, the duration of the examination, and its modality, which might not be tolerated by SARS-CoV-2-infected patients [12].

Huang et al. reported the results of 26 patients, with a median age of 36 years, without notable cardiovascular history, recovering from moderate COVID-19 pneumonia and presenting with a clinical picture suggestive of acute myocarditis. Cardiac MRI was performed within 47 days of the onset of clinical symptoms. Fifteen patients in this study (58% of cases) showed T2 hypersignal and/or late gadolinium enhancement signals. Cardiac edema was observed in 14 patients (54%), while eight patients (31%) had subepicardial late enhancement. This study also highlighted the clinical and biological disparity of concomitant myocarditis in SARS-CoV-2 [13].

B. Etiopathogenic mechanisms

Direct viral multiplication Viral infection of the myocardium is a well-established cause of acute myocarditis, and is even considered the primary etiology of it. Keeping in mind previous experiences with viruses from the same family, including MERS-CoV and SARS-CoV-1, which are implicated in acute myocarditis through direct viral replication, by exploiting the affinity to angiotensin 2 conversion enzymes ACE2 [9, 13, 14]. This has raised the hypothesis of the presumption of the same mechanism with the new coronavirus.

Cytokine storm and autoimmune response Also called "cytokine storm", this inflammatory state is the most severe form of cytokine release syndrome (CRS), characterized by an uncontrolled inflammatory response involving continuous activation of macrophages and lymphocytes [9].

This mechanism is considered the primummovens of the pathogenesis of diffuse lung injury, responsible for acute respiratory distress syndrome [13, 15, 16]. Prolonged inflammatory activation appears to be responsible for triggering an autoimmune response and perpetuating myocardial damage [15, 17].

C. Comorbidities

Our study excluded all patients with comorbidity or cardiovascular risk factors in order to limit interference with other diagnostics. The studies by Luetkens Esposito followed a similar method. Cardiovascular catheterization was systematic in patients to rule out coronary artery disease [18, 19].

Other studies have reported the presence of cardiovascular risk factors and comorbidities. In Huang's study, 8% of patients had only isolated hypertension, while the rates of diabetes and hypertension in Puntmann's study were 22% and 18%, respectively [13, 20].

The low rates of comorbidities and cardiovascular risk factors can be explained by the fact that the population frequently affected by acute myocarditis is a young population [5].

D. Clinical and paraclinical features of COVID-19-associated myocarditis

1. The interval between COVID-19 infection and the onset of cardiac symptoms

Prior to the COVID-19 era, the median time between the onset of flu-like symptoms and acute myocarditis was between one to two weeks [21]. This duration was considered necessary for viruses to replicate within the myocardium and/or trigger an inflammatory or autoimmune response capable of initiating or maintaining acute myocarditis [5]. This variability can be explained by the fact that some authors use the onset of flu-like symptoms as a reference point, while others consider it from the confirmation of SARS-CoV-2 infection.

2. Clinical presentation

Chest pain was reported in 17% to 80% of cases with concurrent acute myocarditis and SARS-CoV-2 [13, 18, 20]. This symptom predominates the clinical presentation with mostly angina-like symptoms, which explains the indication for coronary angiography to rule out acute coronary syndrome [5].

Unexplained and sudden cardiogenic shock following acute myocarditis is characteristic of the fulminant form. Bajaj et al. reported a rate of 33% (3 out of 9 patients), while Wong et al. reported a rate of 47% [22, 23].

Palpitations were a frequent symptom reflecting rhythm and/or conduction disorders. Its incidence varied in the literature between 20% and 88% [13, 20].

3. ECG

Repolarization abnormalities illustrated by diffuse concave ST-segment elevation, ST-segment depression, and T-wave inversion represent the majority of ECG abnormalities reported in acute myocarditis concurrent with COVID-19. They were followed in second place by conduction disorders: atrioventricular block and bundle branch blocks [18, 24].

The predominance of ST-segment or T-wave abnormalities, associated with angina-like chest pain, requires the elimination of coronary artery disease before considering myocarditis, which was done in all the aforementioned studies [13, 20-25] in compliance with recommendations [5].

4. Laboratory tests .

a. Troponin kinetics

The kinetics of cardiac troponin following acute myocarditis has been of interest to several scientific societies, to determine if this kinetics follows a particular pattern allowing differentiation between acute myocarditis and other cardiac diseases, particularly myocardial infarction.

The American Heart Association (AHA) has highlighted the differences in troponin kinetics following acute myocarditis and myocardial infarction. This kinetics tends to normalize rapidly after 2 to 3 days in acute myocarditis, compared to slow normalization in myocardial infarction [26, 27].

In the study by Bajaj et al., the troponin level was high at the time of diagnosis with values ranging from 6 to 208 times the upper limit of normal and normalization of this level within two to five days following the initial peak [22].

b. Inflammatory markers

Various studies have reported disproportionate inflammation during acute myocarditis appearing following SARS-CoV-2 infection, thus suggesting the hypothesis of cytokine storm as a probable mechanism for this condition. The main marker used to assess and monitor inflammation was CRP. The measurement of ferritin, interleukins, and procalcitonin was not systematic [22].

5. ▪Cardiac Imaging .

a. Transthoracic Echocardiography

Bearse's study was the first to provide an anatomical-echocardiographic comparison of myocarditis in SARS-CoV-2. In this study, the ejection fraction was normal in all patients with proven myocarditis, while the ejection fraction was reduced in patients without myocarditis but with detectable viral genome in the myocardium [24]. Although Bajaj et al. reported a decrease in left ventricular ejection fraction in all patients with acute myocarditis, with a mean value of 24% (10%-34%) [23], Wong's study found higher values of LVEF during fulminant and non-fulminant myocarditis [23].

b. Cardiac MRI

Huang's study was the first to detail the results of cardiac MRI in patients with acute myocarditis related to SARS-CoV-2. The systolic ejection fraction was preserved (EF = 60.7 +/- 6.4%), and the functions of the LV and RV were similar to those of the non-affected control group [13]. The same results have been reported by other studies, highlighting the absence of disparity in the systolic and diastolic functions of both ventricles [20,25].

E. Therapeutic, evolutionary and prognostic characteristics

1. Therapeutic characteristics

All our patients received symptomatic treatment based on titrated oxygen therapy, injectable glucocorticoids, antibiotics in case of bacterial superinfection, preventive or therapeutic anticoagulation depending on the patient's risk of thromboembolism, along with vitamin therapy (vitamin C, vitamin D), zinc and adequate hydration. Tocilizumab and Anakinra were used in patients with high IL-6 levels, while no patients received antivirals.

Similar protocols in compliance with WHO recommendations were adopted by other studies similar to ours. Huang's study provided the first therapeutic data of patients with acute myocarditis using early antivirals such as Kaletraand Umifenovir (Arbidol) [13]. The use of antivirals was limited in patients with myocarditis attributed to SARS-CoV-2 with no major differences in outcomes [20, 24].

2. Evolutionary and prognostic characteristics

The current literature does not provide precise data regarding the evolution of patients with acute myocarditis caused by SARS-CoV-2, considering the recent nature of the different studies.

Although Bearse's study was based on pathological reports of deceased patients, the cause of death was acute respiratory distress in relation to COVID-19 without evidence of fulminant myocarditis [24]. In addition, other studies similar to ours did not provide clarification on the short- and long-term evolution of patients.

Post-myocarditic complications, such as dilated cardiomyopathies, are mainly reported in case reports, with no major studies detailing this frequent complication of myocarditis [28, 29].

Although the prognosis of acute myocarditis related to SARS-CoV-2 is still unclear, the presence of myocardial injury is a negative prognostic factor. This injury was found in 7% to 23% of COVID-19 cases and in 50% of patients who died from the disease [9, 15, 17].

F. Study limitations This study presented several limitations:

- The literature on acute myocarditis due to SARS-CoV-2 is still limited.
- Small study sample.
- Delayed diagnosis of myocarditis in COVID-19 patients.
- Incomplete investigations, and therefore, incomplete medical records of COVID-19 patients with a clinical probability of concomitant myocarditis.

V. CONCLUSION

Acute myocarditis is a public health problem, given the epidemiological estimation of this pathology remains poorly understood, it affects a predominantly young population, and its main complications are sudden death and dilated cardiomyopathy.

Our study has allowed us to examine the clinical, biological, radiological, therapeutic, and evolutionary peculiarities of acute myocarditis during SARS-CoV-2 infection, in comparison to data from the literature, and to discuss plausible etiopathogenic mechanisms of this condition, mainly represented by direct viral multiplication, cytokine shock, and induced autoimmune response.

In this regard, our work has revealed certain characteristics of concomitant myocarditis with SARS-CoV-2, such as the delayed interval between infection and onset of cardiac symptoms, the specific kinetics of myocardial injury markers, significant disturbance of the inflammatory balance at the time of diagnosis, and poor prognosis, especially for fulminant forms with high mortality.

Furthermore, our study has highlighted the importance of the availability of cardiac MRI, a key element for confirming the diagnosis in the absence of histological evidence on endomyocardial biopsy.

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