

# Acute chest pain in young patients: report of two cases

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## Abstract

Two clinical cases of young patients with acute chest pain are presented, where the multidisciplinary approach and cardiac magnetic resonance played a crucial role in diagnosis and treatment. **Case presentation 1.** A 20 year old patient with precordial pain and palpitations showed elevated cardiac enzyme levels on laboratory examination. Coronary angiography revealed no significant stenosis. However, the diagnosis of myocarditis was confirmed by cardiac magnetic resonance imaging, which led to the initiation of drug treatment to achieve adequate cardiac function and prevention of disease progression. His clinical evolution was favorable. **Case presentation 2.** 19 year old patient presented with severe chest pain radiating to the left arm and jaw. Laboratory tests reported elevated troponin levels, which raised the suspicion of acute coronary syndrome. Cardiac magnetic resonance imaging confirmed the diagnosis of acute myocardial infarction, and coronary angiography revealed significant stenosis in the anterior descending artery and subsequent ectasia. During hospitalization, a comprehensive therapeutic approach with medication administration, monitoring, pain control, and prevention of complications was provided, and the patient showed a favorable clinical evolution.

## Keywords

Chest Pain, Magnetic Resonance Imaging, Acute Coronary Syndrome, Myocardial Infarction, Myocarditis.

## Resumen

Se presentan dos casos clínicos de pacientes jóvenes con dolor torácico agudo, en ellos, el enfoque multidisciplinario y la resonancia magnética cardíaca jugaron un papel crucial en el diagnóstico y tratamiento. **Presentación del caso 1.** Un paciente de 20 años con dolor precordial y palpitaciones que mostró elevación de los niveles de enzimas cardíacas en los exámenes de laboratorio. La angiografía coronaria no reveló estenosis significativas. Sin embargo, se confirmó el diagnóstico de miocarditis a través de la resonancia magnética cardíaca, lo que llevó al inicio del tratamiento con medicamentos para lograr una función cardíaca adecuada y la prevención del progreso de la enfermedad. Su evolución clínica fue favorable. **Presentación del caso 2.** Un paciente de 19 años que presentó un dolor torácico intenso que se irradiaba al brazo izquierdo y mandíbula. Los exámenes de laboratorio reportaron elevación de los niveles de troponinas, que generaron la sospecha de un síndrome coronario agudo. La resonancia magnética cardíaca confirmó el diagnóstico de un infarto agudo de miocardio, y la angiografía coronaria reveló una estenosis significativa en la arteria descendente anterior y una ectasia subsiguiente. Durante la hospitalización, se brindó un enfoque terapéutico integral con la administración de medicamentos, monitoreo, control del dolor y prevención de complicaciones, y el paciente mostró una evolución clínica favorable.

## Palabras clave

Dolor torácico, Imagen de Resonancia Magnética, Síndrome Coronario Agudo, Infarto Agudo de Miocardio, Miocarditis.

## Introduction

Chest pain is defined as an unpleasant or uncomfortable sensation experienced in the chest that may indicate the presence of a cardiac problem. It is characterized by pres-

sure, tightness, heaviness, and burning and may radiate to the jaw, neck, shoulder, arm, or upper abdomen<sup>1,2</sup>. In the context of studies related to cardiovascular disease, young patients are those under the age of 45 years, as they have a lower cardiovascular risk<sup>33</sup>.



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## Conflict of interests:

The authors declare there are no conflict of interests.

Acute chest pain in young patients is a frequent reason for consultation in the emergency department. In the United States, it is the second most common reason for consultation after trauma; it accounts for more than seven million emergency department visits per year, equivalent to 5 % of all emergency department visits<sup>4,5</sup>. In addition, it causes almost four million outpatient visits per year<sup>1,2</sup>.

There are various causes of chest pain, ranging from musculoskeletal disorders to life-threatening cardiac diseases<sup>1,2</sup>. Due to the complexity of possible causes, timely diagnosis and appropriate treatment are essential to avoid serious consequences. In the young patient, non-cardiac origin is the most frequent, more than 90 % of cases, and it is estimated that 36 % of cases have an idiopathic cause, musculoskeletal 25 %, psychological 16 %, and gastrointestinal 10 %<sup>1,2</sup>.

The initial assessment of patients includes a complete medical history, thorough physical examination, and diagnostic tests such as electrocardiogram (ECG), blood tests, and chest X-ray. However, in some cases, these tests may be insufficient to detect the underlying cause of the pain. In recent years, cardiac magnetic resonance imaging (CMR) has become a valuable tool for the diagnosis of acute chest pain. It allows a more accurate assessment of the possible causes of pain, which can lead to a faster and more accurate diagnosis<sup>6,7</sup>.

This article presents two clinical cases of young patients with acute chest pain that were evaluated at the Rosales National Hospital in El Salvador. Magnetic resonance imaging was used as a complementary study and proved to be a valuable tool in the diagnosis and management of the conditions.

## Case presentation 1

A 20 year old male patient referred from a peripheral hospital with a history of 17 hours of precordial pain accompanied by diaphoresis and palpitations. The precordial pain was oppressive and of moderate intensity, radiating to the left arm. The patient denied having had energy drinks, alcohol, drugs, or tobacco. He had no personal pathological history.

On physical examination, the patient was in good general condition. He had a heart rate of 72 beats per minute, respiratory rate of 16 breaths per minute, blood pressure of 100/70 mm/Hg, temperature of 37 °C, and oxygen saturation of 98 %. At the thoracic level, symmetry was observed, with no pain or masses on palpation. MRI was normal on percussion, and auscultation

showed no abnormal respiratory sounds. A cardiovascular examination revealed a regular heart rhythm with no murmurs. Peripheral pulses were present.

Laboratory tests showed elevated creatine phosphokinase-MB values as well as positive troponins I and T, while all other results were within normal ranges (Table 1). In addition, the ECG showed ST-segment elevation in leads DII, DIII, and aVF (Figure 1). The echocardiogram showed normal function and morphology and a left ventricular ejection fraction (LVEF): 65.5 %. Moreover, coronary angiography revealed no significant stenosis.

Additionally, CMR was performed (Figure 2), which confirmed the diagnosis of myocarditis, excluding an ischaemic pattern. CMR imaging revealed subepicardial oedema in the inferior and inferoseptal region of the mid and apical segments, and late subepicardial gadolinium enhancement was observed. These findings provided valuable information on the extent of inflammation and the presence of structural changes in the myocardium.

## Treatment

Medical treatment was started with enalapril 2.5 mg every 12 hours and carvedilol 6.25 mg every day to reduce afterload and preload, improve ventricular contractile function and prevent the progression of myocarditis.

## Outcome

The patient showed a favorable clinical evolution with medical treatment, with significant improvement of symptoms. After four days of hospitalization, he was discharged in a stable and symptom-free condition, with a recommendation for outpatient follow-up.

After three months, he attended a follow-up consultation where clinical improvement was evident, and CMR showed a decrease in the area of oedema and a reduction in late gadolinium enhancement.

## Diagnosis

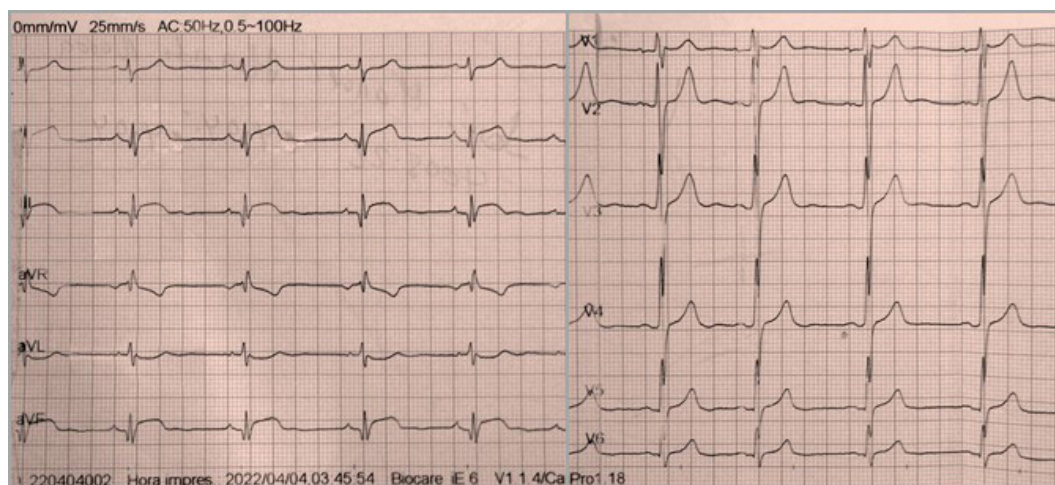
Myocarditis was confirmed by cardiac magnetic resonance imaging.

## Case presentation 2

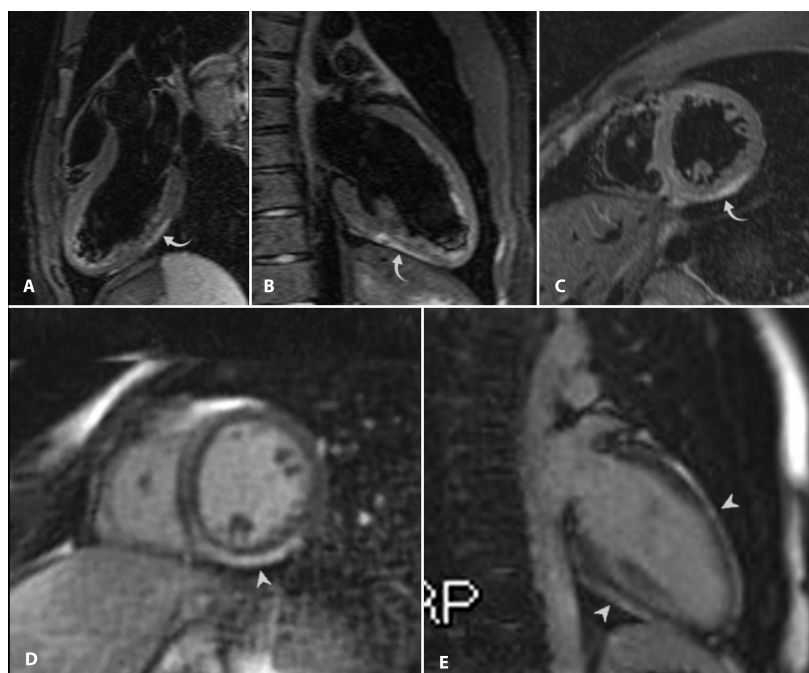
The patient was a 19 year old male who presented with one hour of severe, sudden onset, oppressive retrosternal chest pain radiating to the left arm, jaw, and posterior thorax. He also reported palpitations and a feeling of anguish in the days before the onset. The patient denied having energy

**Table 1.** Laboratory values, case 1

| Laboratory tests | Values                                 | Laboratory tests | Values                                |
|------------------|--|------------------|---------------------------------------|
| CPK-MB           | 100 ng/mL                              | Platelets        | 253 x 10 <sup>3</sup> mm <sup>3</sup> |
| Troponine I      | Positive                               | Creatinine       | 0.79 mg/dL                            |
| Troponine T      | Positive                               | Urea nitrogen    | 6.9 mg/dL                             |
| Leukocytes       | 7.73 x 10 <sup>3</sup> mm <sup>3</sup> | Glucose          | 80 mg/dL                              |
| Neutrophils      | 71.3 %                                 | Sodium           | 145 mEq/L                             |
| Lymphocytes      | 20.7 %                                 | Calcium          | 6.73 mg/dL                            |
| Hemoglobin       | 16.5 g/dL                              | Potassium        | 3.4 mEq/L                             |



**Figure 1.** Electrocardiogram. Sinus rhythm, ST-segment elevation in leads DII, DIII, and aVF, and ST-segment elevation in aVL



**Figure 2.** Cardiac CMR. T2-weighted STIR sequence, three-chamber (A), two-chamber (B), and medial short axis (C) slices. Late enhancement T1-IR sequence with gadolinium, medial short axis (D), and two chambers (E). The images show an increased signal on T2/STIR due to subepicardial oedema (curved arrow) at the level of the inferior and inferoseptal regions of the mid and apical segments (A-C). The images show an increased signal on T2/STIR due to subepicardial oedema (curved arrow) at the level of the inferior and inferoseptal regions of the mid and apical segments (A-C)

or stimulants, alcohol, or drugs. He had no personal medical history.

The patient was acutely ill, haemodynamically stable on the physical examination. He was noted to be in grade I obesity. Vital signs with a heart rate of 72 beats per minute, respiratory rate of 18 breaths per minute, blood pressure of 140/90 mmHg, temperature of 36.0 °C, and oxygen saturation of 93 %. Abnormal breath sounds were not detected. A regular heart rhythm was auscultated with no murmurs, third murmurs, or rubs on cardiovascular examination. Peripheral pulses were palpable, and significant abnormalities were not detected on the rest of the physical examination.

On further examination, an ECG was performed, which showed ST-segment elevation and Q-wave in leads V1-V6 and Q with embryonic R in DI-aVL that indicates a transmural infarction (Figure 3). In addition, troponins I and T were positive and C-reactive protein values were elevated, while all other laboratory tests were normal (Table 2). Therefore, it was classified as acute coronary syndrome (ACS) with ST elevation. An echocardiogram was performed to assess cardiac function and structure, which revealed motility disorders in the apical segment of the heart. CMR was performed due to the possibility of myocarditis or Takotsubo syndrome.

Complementary CMR (Figure 4) confirmed the diagnosis of acute myocardial infarction (AMI) in the territory of the anterior descending artery. Non-viable myocardial tissue was observed, and microvascular obstruction was shown, which indicates severe myocardial injury. In addition, a decreased left ventricular ejection fraction (LVEF) of 41.7 % was observed

A coronary angiography was performed to determine the underlying cause of the

acute myocardial infarction. It revealed 80 % stenosis of ostioproximal of the anterior descending artery with subsequent segment ectasia and a sudden transition to an angiographically normal distal segment (Figure 5). These findings suggested the possibility of a sequela of inadvertent Kawasaki disease during childhood.

## Therapeutic intervention

Thrombolysis with streptokinase was performed, and supportive care was provided with continuous monitoring, pain control, oxygen administration and prevention of thromboembolic complications during hospitalization. In addition, continuous medication with enalapril 10 mg and carvedilol 6.25 mg, both every 12 hours, plus spironolactone 25 mg, clopidogrel 75 mg, atorvastatin 80 mg, furosemide 40 mg and acetylsalicylic acid 100 mg in daily doses.

## Clinical evolution

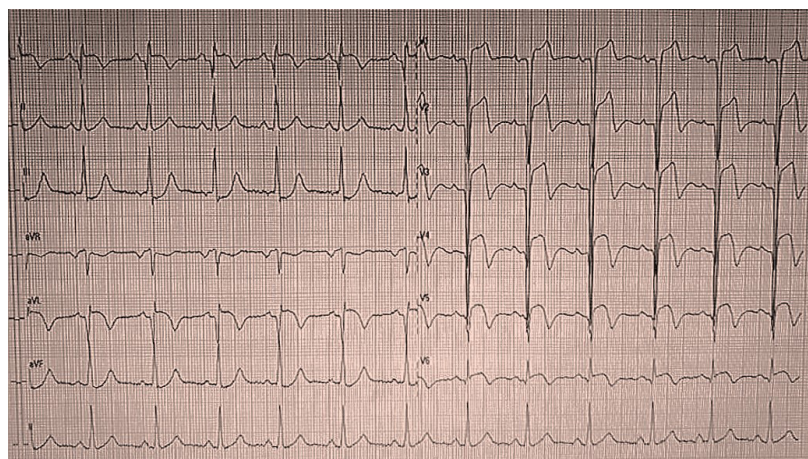
The patient showed a favorable clinical evolution with significant improvement of symptoms. The patient was discharged in stable condition after seven days of hospital stay with an outpatient follow-up plan.

## Diagnosis

Acute myocardial infarction in the territory of the anterior descending artery.

## Discussion

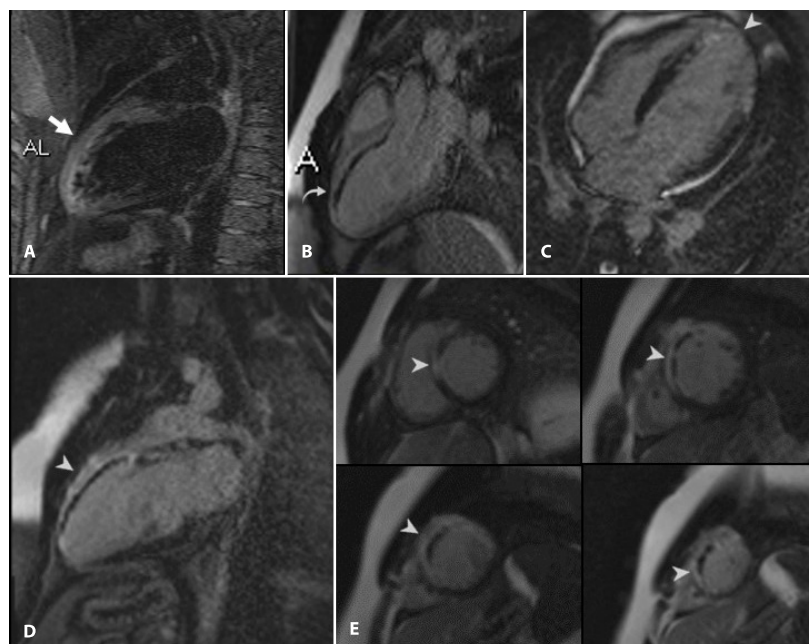
The evaluation of acute chest pain in young patients is a diagnostic challenge due to the wide variety of potential causes. In young patients the non-cardiac cause is more frequent. Therefore, it may have



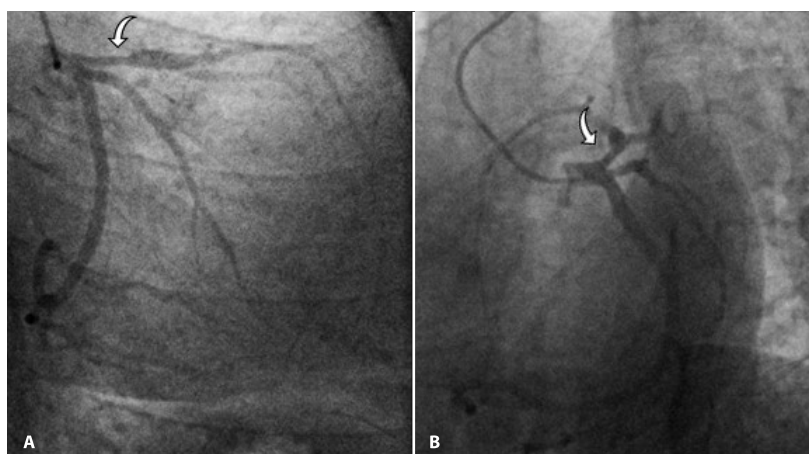
**Figure 3.** Electrocardiogram. Sinus rhythm, J point elevation of 4 mm, and presence of Q wave in V1 - V6. Q wave with embryonic R in DI and AVL

**Table 2.** Laboratory values, case 2

| Laboratory tests | Values                                 | Laboratory tests | Values                                |
|------------------|--|------------------|---------------------------------------|
| Troponine I      | Positive                               | Platelets        | 157 x 10 <sup>3</sup> mm <sup>3</sup> |
| Troponine T      | Positive                               | Creatinine       | 0,82 mg/dL                            |
| Leukocytes       | 9,36 x 10 <sup>3</sup> mm <sup>3</sup> | Glucose          | 100 mg/dL                             |
| Neutrophils      | 74,1 %                                 | Sodium           | 139,6 mEq/L                           |
| Lymphocytes      | 14,9 %                                 | Potassium        | 4,1 mEq/L                             |
| Hemoglobin       | 14,2 g/dL                              | Calcium          | 9,2 mg/dL                             |
| Hematocrit       | 43 %                                   | PCR              | 10,54 mg/dL                           |



**Figure 4.** Cardiac MRI. T2-weighted STIR sequence, two-chamber slices (A). T1-IR sequences of early enhancement with Gadolinium three chambers (B); late enhancement four chambers (C), two chambers (D); and short axis series (E). Sequences show hyperintensity in T2/STIR (straight arrow) due to edema of the anterior wall, the left ventricle basal and medial anteroseptal wall, and the apex in all its segments (A). Early enhancement (curved arrow) from the base to the apex of the septum (B) indicates microvascular obstruction. Pathological transmural late enhancement (arrowheads) of ischemic type in the same segments (C-E)



**Figure 5.** Coronary Angiography. Caudal anteroposterior (A) and caudal left anterior oblique (B) views. Estimated 80 % ostioproximal stenosis (arrows) of the anterior descending artery with subsequent segment ectasia and a sudden transition to an angiographically normal distal segment

socio-cultural causes such as anaerobic exercise, consumption of drugs, carbonated or energy drinks, or it may be idiopathic, the latter resolving spontaneously in 90 % of cases<sup>8</sup>.

Of all ED patients with chest pain, 14 % are patients under 40 years of age, yet patients under 40 years of age account for only 4 % to 8 % of AMIs each year<sup>9</sup>.

It is important that doctors rule out cardiac problems as pain of cardiovascular origin can be lethal and must be thoroughly ruled out. Serious causes include AMI, ventricular arrhythmias, and aortic aneurysm or dissection<sup>8</sup>. The underlying aetiology is diverse, and the atherogenic cause of ischaemic heart disease is not always implicated in the pathogenesis of the disease, so patients often do not present the epidemiological profile to which the clinician is accustomed<sup>2</sup>. Risk factors in young adults are consequences of changing eating behaviors, loss of healthy lifestyle habits, sedentary lifestyles, and stress<sup>2,10</sup>.

Collin *et al.* showed that adults under 40 years of age with chest pain without a known cardiac history and classical cardiac risk factors or with a normal ECG had less than 1 % risk of adverse cardiovascular events at one year<sup>9</sup>.

Kawasaki disease should be considered among the coronary artery diseases that occur in young patients with minimal or no risk factors for atherosclerotic coronary artery disease; therefore, it was considered in our clinical case. Furthermore, it must be suspected when marked ectasia or aneurysm of the proximal coronary arteries with or without calcification is observed, followed by a sudden transition to an angiographically normal distal segment<sup>11</sup>.

International guidelines recommend the exclusion of AMI, risk stratification, and assessment of coronary artery disease in patients with ACS<sup>1,12,13</sup>. In addition, ACS can manifest as unstable angina or acute myocardial infarction and is diagnosed by clinical assessment, electrocardiography, serum cardiac biomarkers, and invasive and non-invasive imaging. Electrocardiographic findings allow for the classification of AMI into AMI with ST-segment elevation and AMI without non-ST-segment elevation.

It is important to measure cardiac biomarkers in blood serum for diagnosis of ACS, as they often increase in patients with AMI<sup>1</sup>. The presence of elevated cardiac biomarker levels and acute chest pain is not limited to AMI alone. Other cardiac diseases can manifest in similar ways, such as myocarditis, Myocardial Infarction with Non-Obstructive Coronary Arteries (MINOCA),

Takotsubo cardiomyopathy, cardiac trauma, tachyarrhythmias, among other conditions<sup>6</sup>. In addition, it is of foremost importance to consider Brugada syndrome as part of the differential diagnosis, characterized by ST-segment elevation in the right precordial leads and increment of the risk of sudden cardiac death<sup>14</sup>.

Imaging studies allow a better assessment, and their choice depends on the clinical question of importance<sup>7</sup>. These studies can be invasive or non-invasive.

Invasive imaging is recommended in patients with non-ST-segment elevation AMI because of the need for immediate reperfusion therapy by percutaneous coronary intervention or thrombolysis<sup>1</sup>. Non-invasive imaging is usually avoided unless aortic dissection or cardiac tamponade is suspected, for which ultrasound is the first imaging modality used<sup>7</sup>.

Non-invasive imaging studies such as CMR may be an option in emergency units to identify patients with non-ST-segment elevation AMI or unstable angina with unobstructed coronary artery disease, especially in those with atypical symptoms or alternative diagnoses, after percutaneous coronary intervention or when the patient's medical history is atypical<sup>6</sup>.

The use of CMR allows for excellent tissue characterization, and in the context of acute ACS, it can accurately assess a variety of parameters that determine regional myocardial dysfunction, infarct distribution, infarct size, myocardium at risk, microvascular obstruction and intramyocardial haemorrhage<sup>6,7</sup>.

In the case of the patient with acute myocardial infarction, CMR helped identify ventricular wall injury and ischaemia in the affected areas, which allowed confirmation of the diagnosis and thus a more accurate assessment of the severity of the disease.

In addition, CMR has important utility in myocarditis detection<sup>6,7,15</sup>, which must be suspected in patients with variable symptoms, including symptoms similar to those of ACS without coronary artery disease and ACS with or without ventricular dysfunction. Myocarditis is the third most common cause of sudden cardiac death and has been associated with 5-12 % of sudden cardiac deaths in young athletes<sup>15</sup>. Although endomyocardial biopsy is the gold standard technique, MRI can diagnose up to 79 % of cases of myocarditis proven by pathology<sup>6</sup>. The Lake Louise criteria are a useful tool for the detection of myocarditis based on the detection of two of three characteristic features: myocardial oedema on T2-weighted MRI, hyperemia on early T1-weighted MRI with

contrast, and fibrosis during late gadolinium enhancement, usually with a non-ischaemic lesion (i.e., in the midwall or subepicardial wall) that does not follow a coronary artery distribution<sup>6</sup>.

In the case of the patient with myocarditis, CMR helped identify myocardial inflammation and rule out other possible causes of acute chest pain, so the patient benefited from targeted treatment with a good prognostic outcome.

In conclusion, the focus on the use of CMR for the diagnosis of ACS patients in both young and adult patients is a promising application that could reduce hospital admissions and costs in the emergency department leading to the possibility of better patient classification<sup>16</sup>. However, there is limited access to such studies, in addition to the requirement for trained cardiac imaging staff and the implementation of rapid protocols for unstable patients requiring acute care to be more widely used in the emergency department.

## Ethical aspects

The cases presented reflect information obtained from clinical records. Patient confidentiality has been ensured in the data collection and analysis of each case. Informed consent has been obtained from both patients and the data in the publication have been used for academic purposes.

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## References

1. Varela D, Palmezano J, Pérez A, Gallego C, Martínez C. Síndrome coronario agudo en el paciente joven. *RCCAR*. 2022;29(3):9166. DOI: [10.24875/RCCAR.M22000160](https://doi.org/10.24875/RCCAR.M22000160)
2. Gulati M, Levy P, Mukherjee D, Amsterdam E, Bhatt D, Birtcher K, *et al*. 2021 AHA/ACC/AASE/CHEST/SAEM/SCCT/SCMR guideline for the evaluation and diagnosis of chest pain: executive summary: a report of the American college of cardiology/ American heart association joint committee on clinical practice guidelines. *JACC* 2021;78(22):2218-2261 DOI: [10.1161/CIR.0000000000001029](https://doi.org/10.1161/CIR.0000000000001029)
3. Sood A, Singh A, Gadkari C. Myocardial infarction in young individuals: a review article. *Cureus*. 2023;15(4):e37102. DOI: [10.7759/cureus.37102](https://doi.org/10.7759/cureus.37102)
4. Anderson H, Masri S, Abdallah M, Chang A, Cohen M, Elgendy I, *et al*. 2022 ACC/AHA Key data elements and definitions for chest pain and acute myocardial infarction: a report of the American Heart Association/ American College of Cardiology Joint Committee on Clinical Data Standards. *Circ Cardiovasc Qual Outcomes*. 2022;15(10). DOI: [10.1161/HCQ.0000000000000112](https://doi.org/10.1161/HCQ.0000000000000112)
5. Curfman G. Acute chest pain in the emergency department. *JAMA Intern Med*. 2018;178(2):220. DOI: [10.1001/jamainternmed.2017.7519](https://doi.org/10.1001/jamainternmed.2017.7519)
6. Broncano J, Bhalla S, Caro P, Hidalgo A, Vargas D, Williamson E, *et al*. Cardiac MRI in patients with acute chest pain. *RadioGraphics*. 2021;41(1):8-31. DOI: [10.1148/rg.2021200084](https://doi.org/10.1148/rg.2021200084)
7. Saremi F. Cardiac MR imaging in acute coronary syndrome: application and image interpretation. *Radiology*. 2017;282(1):17-32. DOI: [10.1148/radiol.2016152849](https://doi.org/10.1148/radiol.2016152849)
8. Quintero E, Balbuena L, Barrera G, Serna D. Dolor precordial en los adolescentes y diagnóstico diferencial de la onda T. *Rev Mex Pediatr*. 2015 82(1):14-17. Available at: <https://www.medigraphic.com/pdfs/pediat/sp-2015/sp151d.pdf>
9. Collin M, Weisenthal B, Walsh K, McCusker C, Shofer F, Hollander J. Young patients with chest pain: 1-year outcomes. *The American Journal of Emergency Medicine*. 2011;29(3):265-270. DOI: [10.1016/j.ajem.2009.09.031](https://doi.org/10.1016/j.ajem.2009.09.031)
10. Garshick M, Vaidean G, Vani A, Underberg J, Newman J, Berger J, *et al*. cardiovascular risk factor control and lifestyle factors in young to middle-aged adults with newly diagnosed obstructive coronary artery disease. *Cardiology*. 2019;142(2):83-90. DOI: [10.1159/000498891](https://doi.org/10.1159/000498891)
11. Bhagwat A, Mukhedkar S, Ekbote S, Gordon J. Missed Kawasaki disease in childhood presenting as myocardial infarction in adults. *IHJ*. 2015;67(4):385-388. DOI: [10.1016/j.ihj.2015.04.014](https://doi.org/10.1016/j.ihj.2015.04.014)
12. Al-Khatib S, Stevenson W, Ackerman M, Bryant W, Callans D, Curtis A, *et al*. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm

- Society. *Circulation*. 2018;138(13):e272-e391. DOI: [10.1161/CIR.0000000000000548](https://doi.org/10.1161/CIR.0000000000000548)
13. Collet J, Thiele H, Barbato E, Barthélémy O, Bauersachs J, Bhatt D, *et al*. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. *Eur. Heart J*. 2021;42(14):1289-1367. DOI: [10.1093/eurheartj/ehaa575](https://doi.org/10.1093/eurheartj/ehaa575)
  14. Probst V, Denjoy I, Meregalli P, Amirault J, Sacher F, Mansourati J, *et al*. Clinical aspects and prognosis of Brugada syndrome in children. *Circulation*. 2007;115(15):2042-2048. DOI: [10.1161/CIRCULATIONAHA.106.664219](https://doi.org/10.1161/CIRCULATIONAHA.106.664219)
  15. Vidal R, Casas C, Agra R, Alvarez B, Grapsa J, Fontes R, *et al*. Myocardial infarction with non-obstructive coronary arteries: A comprehensive review and future research directions. *WJC*. 2019;11(12):305-315. DOI: [10.4330/wjc.v11.i12.305](https://doi.org/10.4330/wjc.v11.i12.305)
  16. Baritussio A, Scatteia A, Bucciarelli C. Role of cardiovascular magnetic resonance in acute and chronic ischemic heart disease. *Int J Cardiovasc Imaging*. 2018;34(1):67-80. DOI: [10.1007/s10554-017-1116-0](https://doi.org/10.1007/s10554-017-1116-0)