MJMR, Vol. 35, No. 1, 2024, pages (274-291).

Open Access
ISSN:2682-4558

*Research Article*

# Cardiac Involvement in children impacted by COVID-19.an observational study

**Moustafa M. Abdel Raheem[1], Marwa Gallab[1], Mostafa Ahmed Elsayed Abuelela[2], and Nagwa M. Sabry Mahmoud[1].**

[1] Department of Pediatrics, Faculty of Medicine, Minia University, Egypt.

[2] Department of Clinical Pathology, Faculty of Medicine, Minia University, Egypt.

**DOI: 10.21608/MJMR.2023.229493.1506**

## Abstract

**Background:** Corona virus disease 2019 (COVID-19) is a contagious disease caused by (SARS-CoV-2). The first known case was identified in Wuhan, China, in December 2019. Since the disease is still spreading quickly around the world and has already claimed nearly 360,000 lives, the World Health Organization (WHO) has determined that corona virus disease 2019 (COVID-19) can be considered a pandemic in March 2020The sequelae of pediatric COVID-19 can affect organs and systems, as cardiovascular system with emphasis on the development of myocarditis, heart failure, cardiogenic shock. **Objective:** This study aimed to assess cardiac complications caused by COVID-19 infection in children. **Patient and methods:** The study is a prospective cross - sectional study included 40 patients admitted to PICU isolation unit in Pediatric Department of Minia University Hospital, during the period from December2021 to December 2022, who were COVID-19 infection with cardiac complications. **Results:** patient investigated for cardiac complication that was (25%) of participants had tachyarrhythmias, while (75%) did not., (30%) participants experienced myocardial dysfunction, while (70%) did not have. (7.5%) of the participants had BBB, while 37(92.5%) did not have. (2.5%) of participants had pan carditis, (97.5%) did not have. (5%) of the participants experienced heart block, while (95%) did not have. (30%) had a mild condition, (42.5%) had a moderate to severe condition, and (27.5%) had a critical condition. **Conclusion:** Cardiovascular issues are emerging as one of the most significant complications of SARS-CoV-2 infection in children.

**Keywords:** COVID 19, MIS-C, ECHO.SARS-CoV-2

## Introduction

Two major outbreaks caused by coronaviruses occurred in 2003 and 2012. [1, 2]. In December 2019, Wuhan, China, saw an epidemic of atypical pneumonia. A brand-new coronavirus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was the culprit behind this pandemic. Later, the coronavirus disease-19 (COVID-19) was named after the illness this virus's connected with. It was determined that COVID-19 was a global pandemic in March of 2020. [3]. SARS-CoV-2 is a single-stranded, positive-sense RNA virus that is enclosed. It causes a wide range of illnesses that affect many different organs. Beginning in May 2020, the disease has spread to over 200 nations and impacted at least 4 million individuals. Over 106 million COVID-19 cases have been confirmed as of 10 February 2021, and there had been more than 2 million fatalities globally. [3,4] Despite having a zoonotic origin, SARS-CoV-2 shows signs of spreading from person to person via droplet, contact, and ocular pathways.

On some surfaces, it can last 72 hours as an aerosol and for three hours as an aerosol. The upper respiratory tract is where the virus most commonly causes respiratory symptoms. However, there is also evidence of multisystem involvement, including the cardiovascular system. In fact, the COVID-19 natural history showed that SARS-CoV-2 may directly affect the cardiovascular system and may make it a key target. The cardiovascular system also suffers indirectly from secondary illness consequences. As a result, it is conceivable that individuals with underlying cardiovascular morbidities are more likely to die and have more severe illness. [5, 6] Cells of a variety of origins, such as lung, cardiac, and intestinal cells, can be directly infected by the virus. Therefore, both direct viral invasion and indirect production of cytokines and inflammatory markers produce tissue injury. The cytokine storm's heightened inflammatory response is a key contributor to the disease's multiorgan involvement. The majority of patients' initial symptoms include fever, a raspy cough, and shortness of breath. As the illness worsens, patients may have vertigo, nausea, vomiting, stomach discomfort, and diarrhea. [6]. 10% of patients have serious illnesses that need intensive care and oxygen support. These individuals are more prone to experience multiorgan failure, acute respiratory distress syndrome, viremia, diffuse alveolar damage, and cardiac injury. [7]. A significant amount of information is now accessible to clarify the mechanism and clinical features of COVID-19 as a result of the rapid progression of events. Only a few researches, meanwhile, give a thorough analysis of cardiovascular symptoms. Furthermore, there is little and inconsistent research on COVID-19 in pediatric popular-tions. This is mainly because children have less severe illness symptoms. In this article, we provide an observational clinical research of COVID-19 in children's cardiovascular symptoms.

## Patient and methods

**Study design:** The present investigation follows a prospective cross-sectional approach, encompassing patients who were admitted to the isolation unit of the Pediatric Intensive Care Unit (PICU) at Minia University Hospital over the period spanning from December 2021 to December 2022. The objective of this study was to assess the cardiac symptoms observed in pediatric patients who have been diagnosed with COVID-19 infection. The research encompassed a cohort of 40 individuals who tested positive for COVID-19 infection and had cardiac problems.

The study included pediatric patients of both genders, ranging in age from one month to 18 years; patients who experienced a severe medical condition that necessitated admission to medical facility and laboratory findings indicate a positive diagnosis of COVID-19 infection. We Excluded those whose age fell below one month or beyond 18 years, there is a lack of laboratory confirmatory evidence for the infection of COVID-19, The laboratory findings indicate a positive COVID-19 infection, however, there is no indication of associated cardiac problems, inability to carry out the necessary laboratory and/or radiographic examinations or lack of approval from the participants' families.

**Ethical considerations:** The present study received clearance from the Ethics Committee of the Faculty of Medicine at Minia University. The procedures employed in this study were conducted in accordance with the appropriate rules and regulations. The research acquired written consent from each parent to participate. Ensure the preservation of the anonymity and confidentiality of the participants. We refrained from employing deceitful methodologies and ensured that participants were had the opportunity to withdraw from our study.

**Data collection procedure:**

All participants underwent the following procedures: Comprehensive collection of patient information, encompassing details such as name, gender, age, place of residence, medical history, and chronic illness history. comprehensive clinical assessment, encom-passing both general and cardiac examinations, should be conducted for all children. The laboratory investigations conducted in this study encompassed many tests, including complete blood counts (CBC), C-reactive protein (CRP), indicators of coagulopathy (D-dimer), serum ferritin, and Troponin. Various radiological studies, such as echocardiography (ECHO) and electrocardiogram (ECG), were conducted.

**Statistical analysis:**

(Using standard computer program): The data was described using measurements such as mean ± standard deviation (SD), minimum and maximum values for quantitative variables, as well as the count and percentage for categorical variables. Statistical analysis was conducted using version 26.0 of the SPSS programmed. The Mann-Whitney test was employed to compare two groups in terms of non-parametric quantitative data. The Chi-Square Test was employed to compare two groups in terms of qualitative data. The Pearson correlation coefficient test was employed to examine the presence of a positive or negative association between two variables. The significance of the results was determined based on the threshold values of $P \leq 0.05$ for significance and $P \leq 0.01$ for high significance.

## Results

This study included 40 patients admitted to the PICU isolation unit in the Pediatric Department of Minia University Hospital. Who were COVID-19 infection-positive and had cardiac complications. In this descriptive statistics report, data was collected from 40 participants. The age of the participants had a median of 6 years with an interquartile range (IQR) of (4-10) years. Regarding gender distribution, 12 participants were male, making up 30% of the sample, while 28 were female, accounting for 70%. The participant's Body Mass Index (BMI) had a mean of 19.2±2.1 with a standard deviation of 2.1. The BMI ranged from (16-22.8). Regarding the participants' residence, 21 lived in urban areas, representing 52.5% of the sample, while 19 lived in rural areas, making up 47.5% of the sample. Regarding their History of exposure, 17 participants tested negative, constituting 42.5% of the sample, while 23 tested positive, representing 57.5% of the sample. The disease duration for the participants had a median of days with an interquartile range (IQR) of (13.1-18.7) days. **(Table 1)**

In this study, the descriptive statistics for various symptoms and conditions were analyzed. 4 participants (10%) did not experience fever or chills, while 36 participants (90%) had these symptoms. Skin rash: 14 participants (35%) did not have a skin rash, whereas 26 participants (65%) had a skin rash. Conjunctivitis: 24 participants (60%) did not have conjunctivitis, while 16 participants (40%) had conjunctivitis.19 participants (47.5%) did not experience vomiting, and 21 participants (52.5%) had vomiting. 12 participants (30%) did not report abdominal pain and 28 participants (70%) had abdominal pain. 16participants (40%) did not have diarrhea, whereas participants 24(60%) had diarrhea. 13 participants (32.5%) did not cough, while 27 participants (67.5%) had a cough. 21 participants (52.5%) did not experience dyspnea, and 19 (47.5%) had dyspnea. 31 participants (77.5%) did not have a cerebrovascular stroke, while 9 participants (22.5%) had this condition. Seizures: 23 participants (57.5%) did not experience seizures, and 17 participants (42.5%) had seizures. The Glasgow Coma Scale (GCS) was also measured, ranging from 4 to 15. The mean ± SD GCS score was 13.1 ± 1.7. Regarding sepsis, 60 participants (75%) did not have sepsis, while 20 participants (25%) had sepsis. Similarly, for shock, 29 participants (72.5%) did not experience shock, and 11 participants (27.5%) had a shock. The disease severity was categorized into three levels: mild, moderate to severe, and critical. Among the participants, 12 (30%) had a mild condition, 17 (42.5%) had a moderate to severe condition, and 11 (27.5%) had a critical condition. **(Table 2)**

Regarding laboratory data we found that ,Hemoglobin (HGB) was from 8 to 15.5 g/dL, with a mean ± SD of 11.3 ± 1.6 g/dL, White Blood Cells (WBCs): Median value was 6.6, with (IQR) ( 5.2 - 7.8), Platelets (PLT): median value was 229, with an IQR ( 187.8 - 337.5), Lymphocytes (%): median value was 22.5, with an IQR ( 15 - 30), Neutrophils (%):was from (35% - 89%), with a mean ± SD of 67 ± 13.2%, Alanine Transaminase (ALT): was from (18 IU/L - 61 IU/L), with a mean ± SD of 29.4 ± 7.7 IU/L, Aspartate Transaminase (AST): was from 18 IU/L to 49 IU/L, with a mean ± SD of 28.2 ± 7.9 IU/L, Albumin: was from 3.5 g/dL to 5 g/dL, with a mean ± SD of 4.2 ± 0.4 g/dL, Total Bilirubin: was from 0.3 mg/dL to 1.1 mg/dL, with a mean ± SD of 0.7 ± 0.2 mg/dL, Direct Bilirubin: was from 0.1 mg/dL to 0.4 mg/dL, with a mean ± SD of 0.2 ± 0.1 mg/dL, International Normalized Ratio (INR): The range of INR was from 1 to 1.1, with a mean ± SD of 1 ± 0, Alkaline Phosphatase (ALP): was

75.5 IU/L, with an IQR of 45.8 to 109.8 IU/L, Creatinine: was from 0.7 mg/dL to 1.6 mg/dL, with a mean ± SD of 1.1 ± 0.2 mg/dL, Troponin Level was found to have median level of 85, with an interquartile range (IQR) of 1.55 to 400. Out of the 40 participants, (65%) of patients tested positive for elevated Troponin levels, while (35%) had negative results, D-dimer: median value was 0.2 μg/mL, with an IQR of 0.1 to 0.8 μg/mL, Ferritin: median value was 410.5 ng/mL, with an IQR of 263 to 539.5 ng/mL, Lactate Dehydrogenase (LDH): was from 188 IU/L to 402 IU/L, with a mean ± SD of 265.8 ± 43.6 IU/L, Erythrocyte Sedimentation Rate (ESR): was from 39 mm/h to 101 mm/h, with a mean ± SD of 69.3 ± 12.5 mm/h, C-reactive Protein (CRP): median value was 71 mg/L, with an IQR of 55.3 to 88.8 mg/L**. (Table 3)** .Furthermore, the presence of COVID-19 IgM and IgG antibodies was examined. Among the participants, (11.3%) tested positive for IgM, while (88.8%) tested positive for IgG. Conversely, (88.8%) tested negative for IgM, and (11.3%) tested negative for IgG. **(Table 3)**

In this descriptive statistics report, and according to CO-RADS classification of COVID-19 in Chest CT, we found that 10 participants, accounting for 25% of the sample, had CO-RAD II, 15 participants, representing 37.5% RAD III, 13 participants, making up 32.5% of the sample had CO-RAD IV, and 2 participants, constituting 5% had CO-RAD V . **(Table 4)**

The descriptive statistics for various treatments and interventions related to COVID-19 were analyzed. Oxygen Therapy: All 40 participants (100%) received oxygen therapy. Mechanical Ventilation: Out of the 40 participants, 16 (40%) required mechanical ventilation, while 24 (60%) did not. Antiviral Treatment was given for 37 participants (92.5%) received antiviral treatment, while only 3 (7.5%) did not received.32 participants (80%) were administered corticosteroids, while 8(20%) did not receive this treatment. Among the participants, 4 (10%) required renal replacement therapy, while only 36 (90%) did not undergo this intervention. These statistics provide valuable insights into using different treatments and therapies for COVID-19 management in the study population. **(Table 5)** The distribution of participants' ECG (Electrocardiogram) findings is as Normal ECG: 60% of the participants had a normal ECG reading, which includes 24 participants. ECG with Arrhythmias: 40% of the participants showed arrhythmias in their ECG, which includes 16 participants. The ECG findings further elaborate on the types of abnormalities observed in the participants who showed Tachyarrhythmias was detected in 5% of the participants (2 individuals). 7.5% of the participants (3 individuals) showed a BBB. 7.5% of the participants (3 individuals) had an A-V block. Prolonged PR interval: 5% of the participants (2 individuals) exhibited a prolonged PR interval. Prolonged QT interval: 5% of the participants (2 individuals) showed a prolonged QT interval. Abnormal ST or T wave segment: 10% of the participants (6 individuals) had abnormal ST or T wave segments. Pathological Q: 2.5% of the participants (1 individual) showed a pathological Q wave. **(Table 6)**

According to ECHO finding, FS (Fractional Shortening) was from 16% to 43%, with a mean of 28.2% and a standard deviation of 6.9%, EF (Ejection Fraction) was from 31% to 73%, with a mean of 55% and a standard deviation of 10.6%, IVSd (Interventricular Septal Thickness in diastole) was from 0.4 cm to 0.8 cm, with a mean of 0.5 cm and a standard deviation of 0.1 cm, LVIDd (Left Ventricular Internal Dimension in diastole) was from 1.7 cm to 3.8 cm, with a mean of 2.9 cm and a standard deviation of 0.5 cm, LVPWd (Left Ventricular Posterior Wall Thickness in diastole) was from 0.5 cm to 0.8 cm, with a mean of 0.5 cm and a standard deviation of 0.2cm, IVSs (Interventricular Septal Thickness in systole) was from 0.2 cm to 0.9 cm, with a mean of 0.5 cm and a standard deviation of 0.1 cm, LVIDs (Left Ventricular Internal Dimension in systole) was from 1.4 cm to 2.9 cm, with a mean of 2 cm and a standard deviation of 0.5 cm, LVPWs (Left Ventricular Posterior Wall Thickness in systole) was from 0.6 cm to 0.8 cm, with a mean of 0.7 cm and a standard deviation of 0.1 cm, EDV (End-Diastolic Volume) was 79 units, with an interquartile range (IQR) of 51.4 to 106 units, ESV (End-Systolic Volume) was 65.8 units, with an interquartile range (IQR) of 40.4

to 93 units and SV (Stroke Volume) was from 46 units to 73 units, with a mean of 62.6 units and a standard deviation of 6.8 units. **(Table 7)**

Cardiac complication that was detected in the studied patients was 10(25%) participants had tachyarrhythmias, while 30(75%) did not. For myocardial dysfunction, 12(30%) participant's experienced myocardial dysfunction, while 28(70%) did not have myocardial dysfunction. Bundle Branch Block (BBB): 3(7.5%) of the participants had BBB, while 37(92.5%) did not have BBB. Patient with Pan Carditis 1(2.5%) of participants had pan carditis, 39 (97.5%) did not have pan carditis. for Heart block 2(5%) of the participants experienced heart block, while 38(95%). did not have a heart block. **(Table 8)**

All studied cases were admitted to the hospital, median hospitalization duration was 17 days, with an interquartile range (IQR) of 11 to 19 days, (62.5%) required admission to the

Intensive Care Unit (ICU), (75%) survived, while (25%) unfortunately succumbed to the disease. (Table 9). This study involving 40 participants examined the descriptive statistics for hospitalization days, ICU admission, and mortality outcomes related to COVID-19. Hospitalization Days showed a median duration of 17 days, with an interquartile range (IQR) of 11 to 19 days. Patients' ICU Admission: Among the participants, 25 (62.5%) required admission to the Intensive Care Unit (ICU), while 15 (37.5%) needed only admission to the isolation unit, not requiring ICU-level care. Mortality: Out of the 40 participants, 30 (75%) survived, while 10 (25%) not survived. (**Table 9)**

**Table 1: Demographic data of all study cases:**

| | **Descriptive statistics N=40** |
|---|---|
| ***Age(years):*** | |
| *Median* | 6 |
| *IQR* | (4-10) |
| **Sex:** | |
| *Male* | 12 (30%) |
| *Female* | 28 (70%) |
| **BMI:** | |
| *Range* | (16-22.8) |
| *Mean ± SD* | 19.2±2.1 |
| **Residence:** | |
| *Urban* | 21 (52.5%) |
| *Rural* | 19 (47.5%) |
| **History of exposure:** | |
| *-Ve* | 17 (42.5%) |
| *+Ve* | 23 (57.5%) |

BMI= Body mass index, IQR= interquartile range

This study included 40 patients admitted to the PICU isolation unit in the Pediatric Department of Minia University Hospital. Who were COVID-19 infection-positive and had cardiac complications. In this descriptive statistics report, data was collected from 40 participants. The age of the participants had a median of 6 years with an interquartile range (IQR) of (4-10) years. Regarding gender distribution, 12 participants were male, making up 30% of the sample, while 28 were female, accounting for 70%. The participant's Body Mass Index (BMI) had a mean of 19.2±2.1 with a standard deviation of 2.1. The BMI ranged from (16-22.8). Regarding the participants' residence, 21 lived in urban areas, representing 52.5% of the sample, while 19 lived in rural areas, making up 47.5% of the sample. Regarding their History of exposure, 17 participants tested negative, constituting 42.5% of the sample, while 23 tested positive, representing 57.5% of the sample. The disease duration for the participants had a median of days with an interquartile range (IQR) of (13.1-18.7) days

**Table 2: Clinical presentation of all study cases:**

| **Constitutional symptoms :** | | **Descriptive statistics N=40** |
|---|---|---|
| **Fever/chills** | *-Ve*<br>*+Ve* | 4(10%)<br>36 (90%) |
| **Skin rash** | *-Ve*<br>*+Ve* | 14(35%)<br>26(65%) |
| **Conjunctivitis** | *-Ve*<br>*+Ve* | 24(60%)<br>16(40%) |
| **GIT Symptoms:** | | |
| **Vomiting** | *-Ve*<br>*+Ve* | 19 (47.5%)<br>21 (52.5%) |
| **Abdominal pain** | *-Ve*<br>*+Ve* | 12(30%)<br>28(70%) |
| **Diarrhea** | *-Ve*<br>*+Ve* | 16(40%)<br>24 (60%) |
| **Respiratory symptoms:** | | |
| **Cough** | *-Ve*<br>*+Ve* | 13 (32.5%)<br>27 (67.5%) |
| **Dyspnea** | *-Ve*<br>*+Ve* | 21 (52.5%)<br>19(47.5%) |
| **CNS Symptoms** | | |
| **Cerebrovascular stroke** | *-Ve*<br>*+Ve* | 31 (77.5%)<br>9(22.5%) |
| **Seizures** | *-Ve*<br>*+Ve* | 23(57.5%)<br>17 (42.5%) |
| **GCS** | *Range*<br>*Mean ± SD* | (5-14)<br>13.2±1.6 |
| **Sepsis** | *-Ve*<br>*+Ve* | 30(75%)<br>10(25%) |
| **Shock** | *-Ve*<br>*+Ve* | 29(72.5%)<br>11(27.5%) |
| **Disease severity** | *Mild*<br>*Moderate to severe*<br>*Critical* | 12 (30%)<br>17(42.5%)<br>11(27.5%) |

GCS=Glasgow coma scale

In this study, the descriptive statistics for various symptoms and conditions were analyzed. 4 participants (10%) did not experience fever or chills, while 36 participants (90%) had these symptoms. Skin rash: 14 participants (35%) did not have a skin rash, whereas 26 participants (65%) had a skin rash. Conjunctivitis: 24 participants (60%) did not have conjunctivitis, while 16 participants (40%) had conjunctivitis.19 participants (47.5%) did not experience vomiting, and 21 participants (52.5%) had vomiting. 12 participants (30%) did not report abdominal pain and 28 participants (70%) had abdominal pain. 16participants (40%) did not have diarrhea, whereas participants 24(60%) had diarrhea. 13 participants (32.5%) did not cough, while 27 participants (67.5%) had a cough. 21 participants (52.5%) did not experience dyspnea, and 19 (47.5%) had dyspnea. 31 participants (77.5%) did not have a cerebrovascular stroke, while 9 participants (22.5%) had this condition. Seizures: 23 participants (57.5%) did not experience seizures, and 17 participants (42.5%) had seizures. The Glasgow Coma Scale (GCS) was also measured, ranging from 4 to 15. The mean ± SD GCS score was 13.1 ± 1.7. Regarding sepsis, 60 participants (75%) did not have sepsis, while 20 participants (25%) had sepsis.

Similarly, for shock, 29 participants (72.5%) did not experience shock, and 11 participants (27.5%) had a shock. The disease severity was categorized into three levels: mild, moderate to severe, and critical. Among the participants, 12 (30%) had a mild condition, 17 (42.5%) had a moderate to severe condition, and 11 (27.5%) had a critical condition.

**Table 3: Laboratory data of all study cases:**

| | | **Descriptive statistics N=40** |
|---|---|---|
| **HGB** | *Range*<br>*Mean ± SD* | (8-15.5)<br>11.3±1.6 |
| **WBCs** | *Median*<br>*IQR* | 6.6<br>(5.2-7.8) |
| **PLT** | *Median*<br>*IQR* | 229<br>(187.8-337.5) |
| **Lymphocytes (%)** | *Median*<br>*IQR* | 22.5<br>(15-30) |
| **Neutrophils (%)** | *Range*<br>*Mean ± SD* | (35-89)<br>67±13.2 |
| **ALT** | *Range*<br>*Mean ± SD* | (18-61)<br>29.4±7.7 |
| **AST** | *Range*<br>*Mean ± SD* | (18-49)<br>28.2±7.9 |
| **Albumin** | *Range*<br>*Mean ± SD* | (3.5-5)<br>4.2±0.4 |
| **Total bilirubin** | *Range*<br>*Mean ± SD* | (0.3-1.1)<br>0.7±0.2 |
| **Direct bilirubin** | *Range*<br>*Mean ± SD* | (0.1-0.4)<br>0.2±0.1 |
| **INR** | *Range*<br>*Mean ± SD* | (1-1.1)<br>1±0 |
| **ALP** | *Median*<br>*IQR* | 75.5<br>(45.8-109.8) |
| **Creatinine** | *Range*<br>*Mean ± SD* | (0.7-1.6)<br>1.1±0.2 |
| **Troponin** | *Median*<br>*IQR* | 185<br>(1.55-400) |
| | *-Ve*<br>*+Ve* | 28(35%)<br>52(65%) |
| **D dimer** | *Median*<br>*IQR* | 0.2<br>(0.1-0.8) |
| **Ferritin** | *Median*<br>*IQR* | 410.5<br>(263-539.5) |
| **LDH** | *Range*<br>*Mean ± SD* | (188-402)<br>265.8±43.6 |
| **ESR** | *Range*<br>*Mean ± SD* | (39-101)<br>69.3±12.5 |
| **CRP** | *Median*<br>*IQR* | 71<br>(55.3-88.8) |
| **COVID-19 IgM** | *-Ve*<br>*+Ve* | 9(11.3%)<br>71(88.8%) |
| **COVID-19 IgG** | *-Ve*<br>*+Ve* | 71(88.8%)<br>9(11.3%) |

WBCS= white blood cells, ALT= alanine transaminase, AST= aspartate transaminase, ALP= alkaline phosphatase, LDH=lactate dehydrogenase, ESR= erythrocyte sedimentation rate, CRP = C-reactive protein

Regarding laboratory data we found that ,Hemoglobin (HGB) was from 8 to 15.5 g/dL, with a mean ± SD of 11.3 ± 1.6 g/dL, White Blood Cells (WBCs): Median value was 6.6, with (IQR) (5.2 - 7.8),Platelets (PLT): median value was 229, with an IQR ( 187.8 - 337.5), Lymphocytes (%): median value was 22.5, with an IQR ( 15 - 30), Neutrophils (%):was from (35% - 89%), with a mean ± SD of 67 ± 13.2%, Alanine Transaminase (ALT): was from (18 IU/L - 61 IU/L), with a mean ± SD of 29.4 ± 7.7 IU/L, Aspartate Transaminase (AST): was from 18 IU/L to 49 IU/L, with a mean ± SD of 28.2 ± 7.9 IU/L, Albumin: was from 3.5 g/dL to 5 g/dL, with a mean ± SD of 4.2 ± 0.4 g/dL, Total Bilirubin: was from 0.3 mg/dL to 1.1 mg/dL, with a mean ± SD of 0.7 ± 0.2 mg/dL, Direct Bilirubin: was from 0.1 mg/dL to 0.4 mg/dL, with a mean ± SD of 0.2 ± 0.1 mg/dL, International Normalized Ratio (INR): The range of INR was from 1 to 1.1, with a mean ± SD of 1 ± 0, Alkaline Phosphatase (ALP): was 75.5 IU/L, with an IQR of 45.8 to 109.8 IU/L, Creatinine: was from 0.7 mg/dL to 1.6 mg/dL, with a mean ± SD of 1.1 ± 0.2 mg/dL, Troponin Level was found to have median level of 85, with an interquartile range (IQR) of 1.55 to 400. Out of the 40 participants, (65%) of patients tested positive for elevated Troponin levels, while (35%) had negative results, D-dimer: median value was 0.2 µg/mL, with an IQR of 0.1 to 0.8 µg/mL, Ferritin: median value was 410.5 ng/mL, with an IQR of 263 to 539.5 ng/mL, Lactate Dehydrogenase (LDH): was from 188 IU/L to 402 IU/L, with a mean ± SD of 265.8 ± 43.6 IU/L, Erythrocyte Sedimentation Rate (ESR): was from 39 mm/h to 101 mm/h, with a mean ± SD of 69.3 ± 12.5 mm/h, C-reactive Protein (CRP): median value was 71 mg/L, with an IQR of 55.3 to 88.8 mg/L**.**

Furthermore, the presence of COVID-19 IgM and IgG antibodies was examined. Among the participants, (11.3%) tested positive for IgM, while (88.8%) tested positive for IgG. Conversely, (88.8%) tested negative for IgM, and (11.3%) tested negative for IgG.

**Table 4: CT grading in all study cases:**

| | | **Descriptive statistics N=40** |
|---|---|---|
| **CT Chest** | *Grade II* | 10 (25%) |
| | *Grade III* | 15 (37.5%) |
| | *Grade IV* | 13 (32.5%) |
| | *Grade V* | 2(5%) |

*CT = computerized tomography*

In this descriptive statistics report, and according to CO-RADS classification of COVID-19 in Chest CT, we found that 10 participants, accounting for 25% of the sample, had CO-RAD II, 15 participants, representing 37.5% RAD III, 13 participants, making up 32.5% of the sample had CO-RAD IV, and 2 participants, constituting 5% had CO-RAD V

**Table 5: Treatment protocols used in all study cases:**

| | | Descriptive statistics N=40 |
|---|---|---|
| **Oxygen therapy** | *-Ve*<br>*+Ve* | 0(0%)<br>40(100%) |
| **Mechanical ventilation** | *-Ve*<br>*+Ve* | 24 (60%)<br>16 (40 %) |
| **Antiviral** | *-Ve*<br>*+Ve* | 3(7.5%)<br>37(92.5%) |
| **Corticosteroids** | *-Ve*<br>*+Ve* | 8(20%)<br>32(80%) |
| **Renal replacement therapy** | *-Ve*<br>*+Ve* | 36(90%)<br>4(10%) |

The descriptive statistics for various treatments and interventions related to COVID-19 were analyzed. Oxygen Therapy: All 40 participants (100%) received oxygen therapy. Mechanical Ventilation: Out of the 40 participants, 16 (40%) required mechanical ventilation, while 24 (60%) did not. Antiviral Treatment was given for 37 participants (92.5%) received antiviral treatment, while only 3 (7.5%) did not received.32 participants (80%) were administered corticosteroids, while 8(20%) did not receive this treatment. Among the participants, 4 (10%) required renal replacement therapy, while only 36 (90%) did not undergo this intervention. These statistics provide valuable insights into using different treatments and therapies for COVID-19 management in the study population

**Table 6: ECG of all study cases:**

| | | Descriptive statistics N=40 |
|---|---|---|
| **ECG** | *Normal*<br>*Arrhythmias* | 24(60%)<br>16(40%) |
| | *Normal*<br>*Tachyarrhythmias*<br>*BBB*<br>*A-V block*<br>*Prolonged PR interval*<br>*Prolonged QT interval*<br>*Abnormal ST or T wave segment*<br>*Pathological Q* | 24(58.8%)<br>2(5%)<br>3(7.5%)<br>3(7.5%)<br>2(5%)<br>2(5%)<br>6(10%)<br>1(2.5%) |

ECG= Electrocardiogram, BBB= Bundle branch block, A-V block= atrioventricular block.

The distribution of participants' ECG (Electrocardiogram) findings is as Normal ECG: 60% of the participants had a normal ECG reading, which includes 24 participants. ECG with Arrhythmias: 40% of the participants showed arrhythmias in their ECG, which includes 16 participants. The ECG findings further elaborate on the types of abnormalities observed in the participants who showed Tachyarrhythmias was detected in 5% of the participants (2 individuals). 7.5% of the participants (3 individuals) showed a BBB. 7.5% of the participants (3 individuals) had an A-V block.Prolonged PR interval: 5% of the participants (2 individuals) exhibited a prolonged PR interval. Prolonged QT interval: 5% of the participants (2 individuals) showed a prolonged QT interval. Abnormal ST or T wave segment: 10% of the participants (6 individuals) had abnormal ST or T wave segments. Pathological Q: 2.5% of the participants (1 individual) showed a pathological Q wave

**Table 7: Echocardiography of all study cases:**

| | | **Descriptive statistics N=40** |
|---|---|---|
| **FS** | *Range*<br>*Mean ± SD* | (16-43)<br>28.2±6.9 |
| **EF** | *Range*<br>*Mean ± SD* | (31-73)<br>55±10.6 |
| **IVSd** | *Range*<br>*Mean ± SD* | (0.4-0.8)<br>0.5±0.1 |
| **LVIDd** | *Range*<br>*Mean ± SD* | (1.7-3.8)<br>2.9±0.5 |
| **LVPWd** | *Range*<br>*Mean ± SD* | (0.5-0.8)<br>0.5±0.2 |
| **IVSs** | *Range*<br>*Mean ± SD* | (0.2-0.9)<br>0.5±0.1 |
| **LVIDs** | *Range*<br>*Mean ± SD* | (1.4-2.9)<br>2±0.5 |
| **LVPWs** | *Range*<br>*Mean ± SD* | (0.6-0.8)<br>0.7±0.1 |
| **EDV** | *Median*<br>*IQR* | 79<br>(51.4-106) |
| **ESV** | *Median*<br>*IQR* | 65.8<br>(40.4-93) |
| **SV** | *Range*<br>*Mean ± SD* | (46-73)<br>62.6±6.8 |

IVSD= Interventricular Septal Thickness in diastole, FS =Fractional Shortening, EF =Ejection Fraction, LVIDD =Left Ventricular Internal Dimension in diastole, LVPWd =Left Ventricular Posterior Wall Thickness in diastole, LVIDs= Left Ventricular Internal dimension in systole, IVSs =Interventricular Septal Thickness in systole, LVPWs =Left Ventricular Posterior Wall Thickness in systole, EDV =End-Diastolic Volume, ESV =End-Systolic Volume, SV =Stroke Volume.

According to ECHO finding, FS (Fractional Shortening) was from 16% to 43%, with a mean of 28.2% and a standard deviation of 6.9%, EF (Ejection Fraction) was from 31% to 73%, with a mean of 55% and a standard deviation of 10.6%, IVSd (Interventricular Septal Thickness in diastole) was from 0.4 cm to 0.8 cm, with a mean of 0.5 cm and a standard deviation of 0.1 cm, LVIDd (Left Ventricular Internal Dimension in diastole) was from 1.7 cm to 3.8 cm, with a mean of 2.9 cm and a standard deviation of 0.5 cm, LVPWd (Left Ventricular Posterior Wall Thickness in diastole) was from 0.5 cm to 0.8 cm, with a mean of 0.5 cm and a standard deviation of 0.2 cm, IVSs (Interventricular Septal Thickness in systole) was from 0.2 cm to 0.9 cm, with a mean of 0.5 cm and a standard deviation of 0.1 cm, LVIDs (Left Ventricular Internal Dimension in systole) was from 1.4 cm to 2.9 cm, with a mean of 2 cm and a standard deviation of 0.5 cm, LVPWs (Left Ventricular Posterior Wall Thickness in systole) was from 0.6 cm to 0.8 cm, with a mean of 0.7 cm and a standard deviation of 0.1 cm, EDV (End-Diastolic Volume) was 79 units, with an interquartile range (IQR) of 51.4 to 106 units, ESV (End-Systolic Volume) was 65.8 units, with an interquartile range (IQR) of 40.4 to 93 units and SV (Stroke Volume) was from 46 units to 73 units, with a mean of 62.6 units and a standard deviation of 6.8 units

**Table 8: Frequency of cardiac complications in all study cases:**

| | | Descriptive statistics N=40 |
|---|---|---|
| **Tachyarrhythmias** | *-Ve*<br>*+Ve* | 30(75%)<br>10(25%) |
| **Myocardial disfunction** | *-Ve*<br>*+Ve* | 28(70%)<br>12(30%) |
| **BBB** | *-Ve*<br>*+Ve* | 37(92.5%)<br>3(7.5%) |
| **Pan carditis** | *-Ve*<br>*+Ve* | 39 (97.5%)<br>1(2.5%) |
| **Heart block** | *-Ve*<br>*+Ve* | 38(95%)<br>2(5%) |

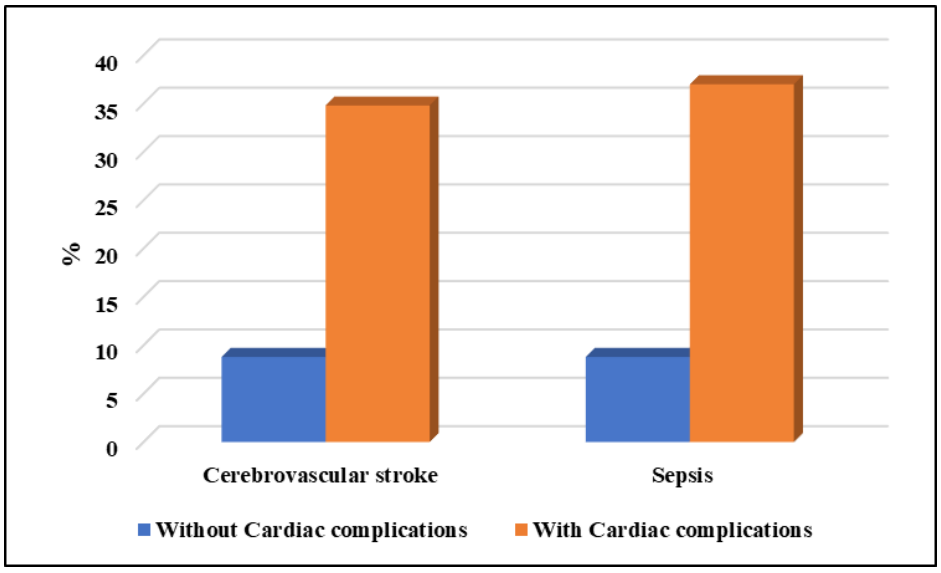
BBB= Bundle Branch Block

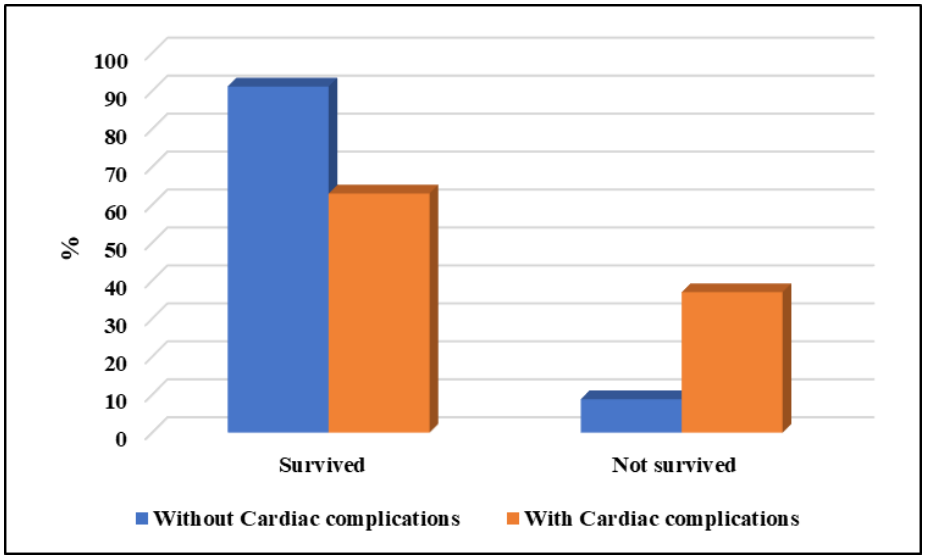
Cardiac complication that was detected in the studied patients was 10(25%) participants had tachyarrhythmias, while 30(75%) did not. For Myocardial dysfunction, 12(30%) participants experienced myocardial dysfunction, while 28(70%). Did not have myocardial dysfunction. Bundle Branch Block (BBB): 3(7.5%) of the participants had BBB, while 37(92.5%) did not have BBB. patient with Pan carditis 1(2.5%) of participants had pan carditis, 39 (97.5%) did not have pan carditis. for Heart block 2(5%) of the participants experienced heart block, while 38(95%). did not have a heart block.

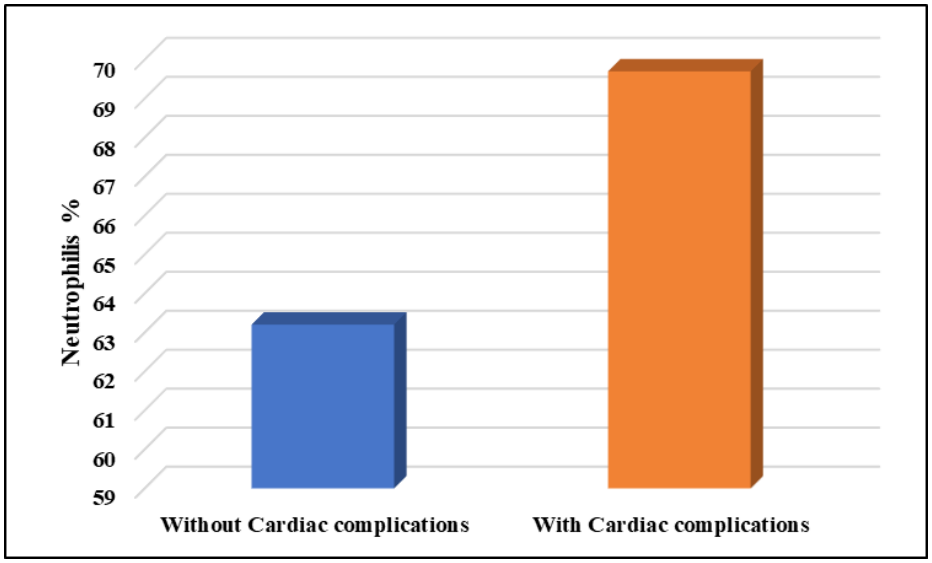
**Table 9: Outcome presentation in all study cases:**

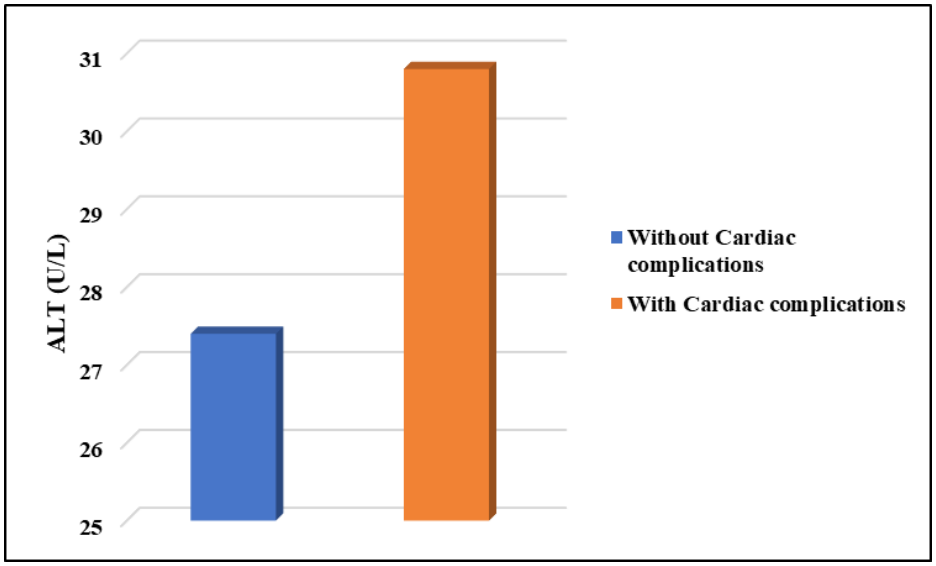
| | | Descriptive statistics N=40 |
|---|---|---|
| **Hospitalization days** | *Median*<br>*IQR* | 17<br>(11-19) |
| **ICU** | *-Ve*<br>*+Ve* | 15 (37.5%)<br>25(62.5%) |
| **Mortality** | *Survived*<br>*Died* | 30(75%)<br>10(25%) |

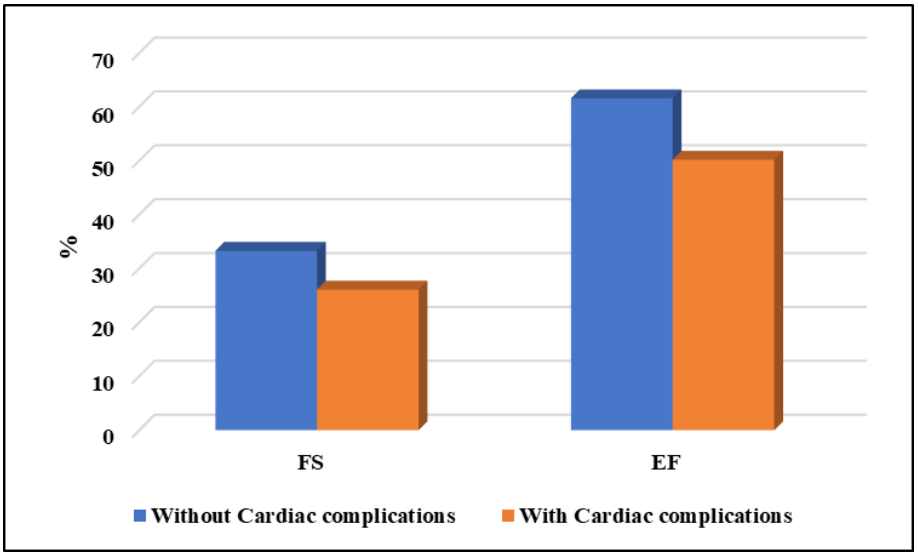
ICU= intensive care unites

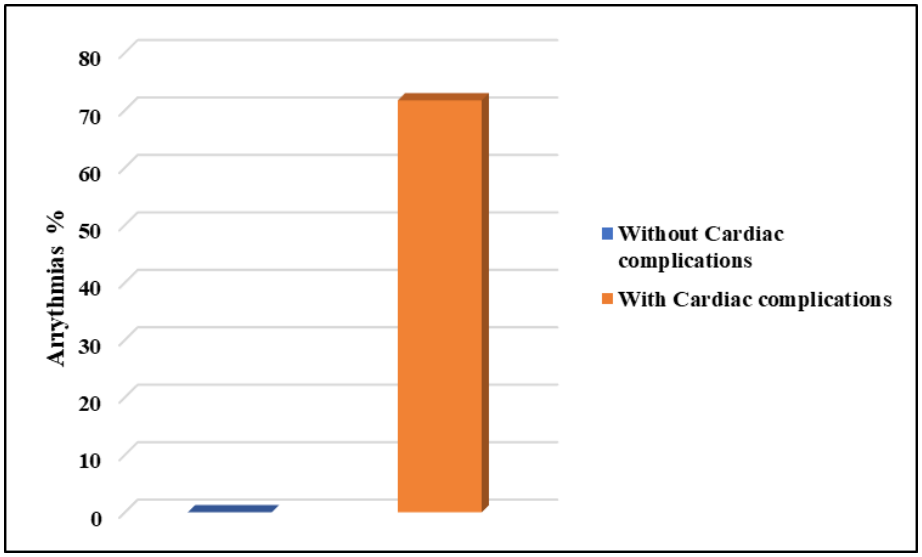


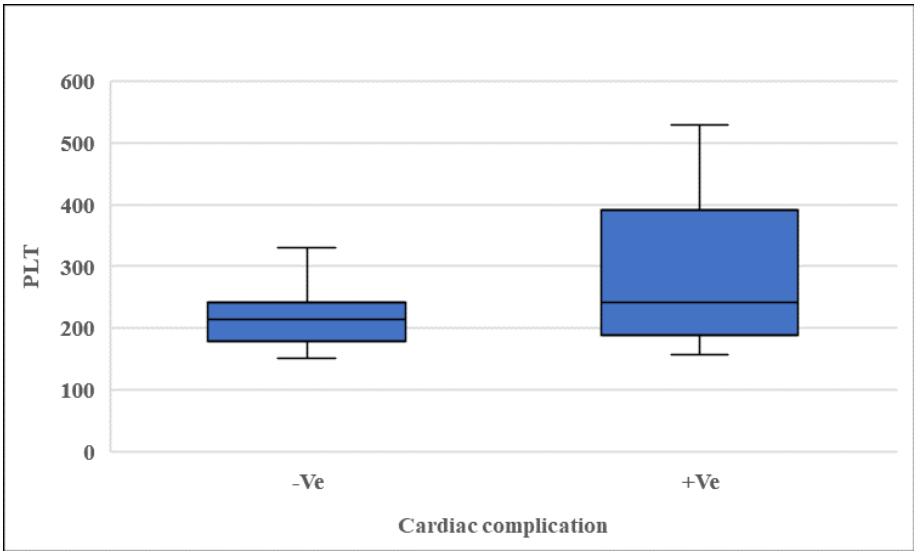

100
90
80
70
60
50
40
30
20
10
0
%
Survived
Not survived
Without Cardiac complications
With Cardiac complications

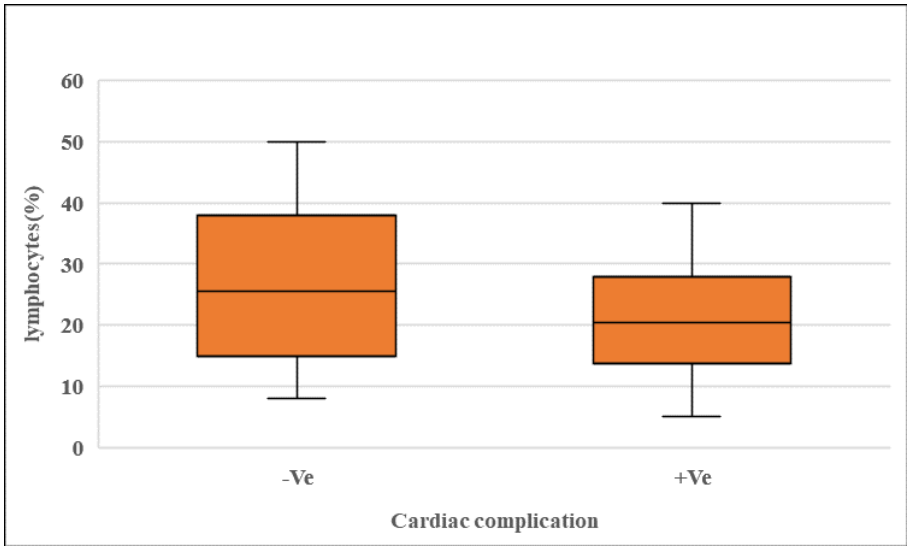

70
69
68
67
66
65
64
63
62
61
60
59
Neutrophilis %
Without Cardiac complications
With Cardiac complications

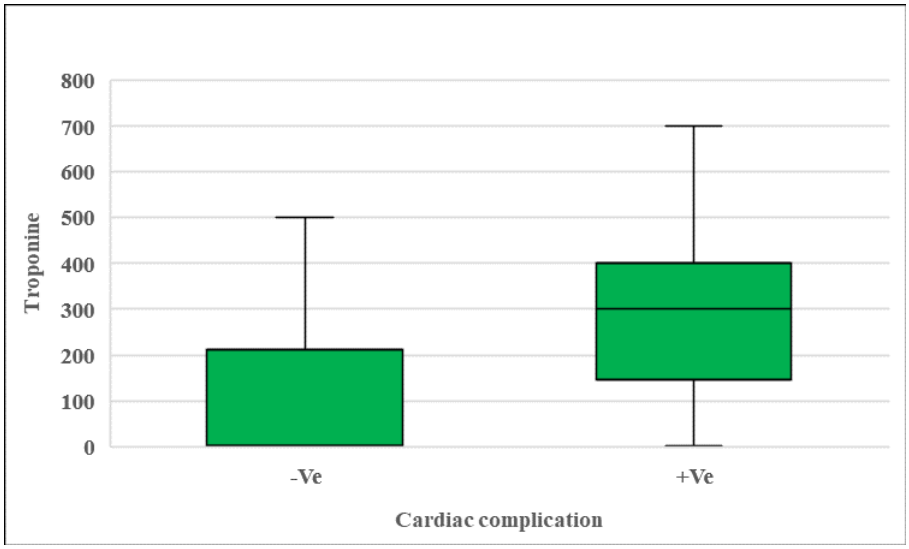

31
30
29
28
27
26
25
ALT (U/L)
Without Cardiac complications
With Cardiac complications


70
60
50
40
30
20
10
0
%
FS
EF
Without Cardiac complications
With Cardiac complications


80
70
60
50
40
30
20
10
0
Arrythmias %
Without Cardiac complications
With Cardiac complications


600
500
400
300
200
100
0
PLT
-Ve
+Ve
Cardiac complication




All studied cases were admitted to the hospital, median hospitalization duration was 17 days, with an interquartile range (IQR) of 11 to 19 days, (62.5%) required admission to the Intensive Care Unit (ICU), (75%) survived, while (25%) unfortunately succumbed to the disease. (Table 9). This study involving 40 participants examined the descriptive statistics for hospitalization days, ICU admission, and mortality outcomes related to COVID-19. Hospitalization Days showed a median duration of 17 days, with an interquartile range (IQR) of 11 to 19 days. Patients' ICU Admission: Among the participants, 25 (62.5%) required admission to the Intensive Care Unit (ICU), while 15 (37.5%) needed only admission to the isolation unit, not requiring ICU-level care. Mortality: Out of the 40 participants, 30 (75%) survived, while 10 (25%) not survived

## Discussion

The coronavirus known as SARS-CoV-2, which causes severe acute respiratory syndrome, is the cause of COVID-19 (coronavirus disease of 2019). In Wuhan, China, authorities discovered the first recorded case in December 2019. The following global spread of the sickness resulted in a continuing epidemic.[8, 9] Pediatric COVID-19 complications can have an impact on a variety of organs and systems, including the cardiovascular system. Actually, the majority of patients had cardiac issues connected to MIS-C. [10] Myocarditis is frequently identified clinically by electrocardiograms, echocardiography, and increased

cardiac enzymes since troponin is thought to be an indication of heart injury in children and adolescents.[11] The increase in cardiac biomarkers is accompanied by an increase in inflammatory markers, and it is linked to heart damage. Poorer clinical outcomes and higher rates of morbidity and death are experienced in that order.[12]. During the months of December 2021 and December 2022, 40 patients were admitted to our PICU for our research. For the occurrence of cardiac problems, all patients that were shown to have COVID-19 infection were examined.40 patients with were enrolled in our research. With an interquartile range (IQR) of (4–10) years and a median age of 6 years, the participants' ages fell within this range. approval of (EinatBlumfield & Terry L. Levin)[13] who found that the mean age of COVID-19 infection in children is 7 years. In terms of gender distribution, 28 female participants made up 70% of the sample, compared to 12 male participants, which was in line with (Götzinger, Florian, et al. (2020)).[14]

The risk model for the cardiac complication was constructed in this study after clinical factors and patterns of cardiac complications for COVID-19 were identified. Our research also revealed that 57.5% of the cases examined were children who had COVID-19 and its related cardiac problems. While 17 (42.5%) of the subjects had no cardiac problems, 23 (57.5%) of the patients did. Thirty of the subjects (75%) did not have tachyarrhythmias, compared to ten (25%) who did. 28 (70%) of the patients did not have myocardial dysfunction, compared to 12 (30%). myocardial dysfunction is not present. Bundle Branch Block (BBB) was present in 3 (7.5%) persons but not in 37 (92.5%). a person with Pan Carditis 39 (97.5%) of the subjects were free of pan carditis, compared to 1 (2.5%) who did. 2 (5%) of the patients had cardiac problems, in agreement with (Valverde, Israel, et al., 2021).[15] They discovered that 34 percent of patients had impaired EF, also in agreement with( Song, Mi Kyoung, and Bryan Kwon (2023) [16] who discovered that tachyarrhythmia was recorded in juvenile patients at an incidence of (0%-17%).

The median troponin level in our sample was 85, with an interquartile range (IQR) of 1.55 to 400. The results of the 40 participants showed that (65%) of the patients had high Troponin levels, whereas (35%) had negative results. This was consistent with (Tersalvi, G et al., 2020)[17] who discovered that individuals with COVID-19 frequently had elevated troponin levels, which are strongly linked to cardiac problems. All cases were hospitalized; the median duration of stay was 17 days; the interquartile range (IQR) ranged from 11 to 19 days; 62.5 percent of cases necessitated admission to the intensive care unit (ICU); 75 percent of patients recovered; and 25 percent of patients passed away from the illness. (Table 9). Descriptive statistics for COVID-19-related hospitalization days, ICU admission, and death outcomes were studied in this 40-participant research. With an interquartile range (IQR) of 11 to 19 days, the median hospital stays lasted 17 days. Patients' intensive care unit of the participants, 25 (62.5%) needed to be admitted to the intensive care unit (ICU), whereas 15 (37.5%) merely needed to be admitted to the isolation unit and did not, [18] 16.7% developed arrhythmia and 7.2% developed acute cardiac injury, cardiac complications were prevalent among hospitalized patients with COVID19. In a separate series of 41 hospitalized patients with COVID19, 5% were diagnosed with acute cardiac injury (ACI).[18-21]

The cardiovascular complications of severe acute respiratory syndrome are similar to those of COVID19 and include hypotension, tachycardia, arrhythmias, systolic and diastolic dysfunctions, and sudden death, with tachycardia being the most prevalent condition that lasts for almost 40% of patients during follow-up.[22] MERS has also been connected to myocarditis and cardiac harm.[23]However, there are still few case studies describing severe acute respiratory syndrome with increased cardiac enzymes and myocardial damage indicators. A clinical bulletin from the American College of Cardiology warned that underdiagnosis due to classic symptoms and the potential overshadowing of cardiac complications in the context of coronavirus should be avoided. This is because long-term outcomes of COVID19 patients with cardiac complications need to be further validated.[24] the underlying causes and long-term consequences of cardiac problems in COVID19 patients are yet unclear. Interleukin1, interleukin6, interleukin12, interferon gamma, interferon inducible protein, 18,

and monocyte chemoattractant protein 1 (MCP1) are examples of proinflammatory cytokines with elevated serum levels that suggest severe acute respiratory syndrome coronavirus 2 (SARSCoV2) infection is linked to cellular immune deficiency and coagulation activation.18 Therefore, it is thought that the primary pathophysiological processes behind SARSCoV2 infection are the direct impacts of the virus, the cytokine storm brought on by viral invasion, and the persistent inflammatory response-induced fulminant myocarditis. No survivors had higher rates of heart failure (52%) or ACI (58%) in a study of 191 patients with COVID19, but the main reasons were respiratory failure, myocardial lesions, and circulatory failure.[25, 26]Myocarditis was also detected by cardiac magnetic resonance imaging in a COVID19 patient whose upper respiratory infection had resolved.[27] Previous research has demonstrated that the severe acute respiratory syndrome coronavirus can cause myocardial injury and damage linked to the down regulation of the myocardial ACE-2 system. This may explain myocardial dysfunction and unfavorable cardiac outcomes in patients with severe acute respiratory syndrome, which has also been detected in COVID19 patients.[28-32 ]Until recently, the pathogenesis of the MERS coronavirus, which causes severe acute respiratory syndrome, was not completely known. Although whole genome sequencing and phylogenic analysis have shown that SARSCoV2 is similar to severe acute respiratory syndrome coronavirus and MERS coronavirus, more study is required to confirm the path physiological mechanism of cardiac infection or injury brought on by SARSCoV2.[33]

There are certain restrictions on our study. First off, this is a somewhat small sample of pediatric COVID19 patients that are hospitalized; more standardized data from a bigger cohort would be helpful for characterizing the clinical parameters in more depth. Secondly, our findings demonstrated the clinical features of COVID19-related cardiac problems, such as clinical symptoms, electrophysiological abnormalities, myocardial enzyme and damage marker levels, and cardiac dysfunction and hypertrophy. The results of cardiovascular magnetic resonance imaging would have inevitably strengthened our study (and confirmed the possibility of myocardial edema, necrosis, and/or micro vascular impairment; however, cardiac magnetic resonance was not practical in the acute setting due to infection control restrictions).

**Conclusion:**

In the context of people who have been diagnosed with COVID-19, the addition of cardiovascular variables has significant predictive value. Cardiology services must be included in multidisciplinary teams if COVID-19 patients are to receive complete issue care. In conclusion, our argument is that ensuring enough financing for early detection and effective treatment of cardiac issues is crucial for reducing morbidity and death linked to cardiovascular sequelae. Additionally, it is crucial to perform a thorough evaluation that includes an ECG, an echocardiography, and a basic cardiac workup in order to quickly detect and treat the disease.

**Declarations:**

- **Ethics approval:** This study was approved by the ethical committee, faculty of medicine; all methods were performed in accordance with the relevant guidelines and regulations by including a statement.
- **Consent to participate:** A written consent was obtained from each parent to agree to participate in the study. Protect the participant's anonymity and confidentiality. Avoiding using deceptive practices. Giving participants the right to withdraw from our research. Consent for publication was taken.
- **Consent for publication:** Not applicable
- **Availability of data and materials:** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.
- **Competing interests:** We declared no conflict of interest concerning the study
- **Funding:** No funding agency is providing us with assistance for this project in the form of funds. The authors paid for the study out of their own pockets.
- **Acknowledgments:** None.

## References


1. S. Perlman, "Another decade, another coronavirus," New England Journal of Medicine, vol.382, no.8,pp.760–762, 2020.
2. A. M. Zaki, S. van Boheemen, T. M. Bestebroer, A. D. M. E. Osterhaus, and R. A. M. Fouchier, "Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia," New England Journal of Medicine, vol. 367, no. 19, pp. 1814–1820, 2012.
3. WHO, World Health Organization Coronavirus Disease 2019 (COVID-19): Situation Report–113, WHO, Geneva, Switzerland, 2020.
4. N. K. Younis, R. O. Zareef, S. N. Al Hassan, F. Bitar, A. H. Eid, and M. Arabi, "Hydroxychloroquine in COVID-19 patients: pros and cons," Frontiers in Pharmacology, vol. 11, Article ID 597985, 2020.
5. N. van Doremalen, T. Bushmaker, D. H. Morris et al., "Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1," New England Journal of Medicine, vol. 382, no. 16, pp.1564–1567, 2020.
6. W. Tan and J. Aboulhosn, "The cardiovascular burden of coronavirus disease 2019 (COVID-19) with a focus on congenital heart disease," International Journal of Cardiology, vol. 309, pp. 70–77, 2020.
7. C. Huang, Y. Wang, X. Li et al., "Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China," The Lancet,vol.395,no.10223,pp.497-506,2020
8. Li, Q., et al., Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. New England journal of medicine, 2020. 382(13): p. 1199-1207.
9. Wang, D., et al., Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. jama, 2020. 323(11): p. 1061-1069.
10. Sperotto, F., et al., Cardiac manifestations in SARS-CoV-2-associated multisystem inflammatory syndrome in children: a comprehensive review and proposed clinical approach. European journal of pediatrics, 2021. 180: p. 307-322.
11. Wolfler, A., et al., Acute myocardial injury: a novel clinical pattern in children with COVID-19. The Lancet Child & Adolescent Health, 2020. 4(8): p. e26-e27.
12. Shi, S., et al., Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. JAMA cardiology, 2020. 5(7): p. 802-810.
13. Blumfield, E. and T.L. Levin, COVID-19 in pediatric patients: a case series from the Bronx, NY. Pediatric radiology, 2020. 50: p. 1369-1374.
14. Götzinger, F., et al., COVID-19 in children and adolescents in Europe: a multinational, multicentre cohort study. The Lancet Child & Adolescent Health,2020.4(9):p.653-661.
15. Valverde, I., et al., Acute cardiovascular manifestations in 286 children with multisystem inflammatory syndrome associated with COVID-19 infection in Europe. Circulation, 2021. 143(1): p.21-32.
16. Song, M.K. and B. Kwon, Arrhythmia and COVID-19 in children. Clinical and Experimental Pediatrics,2023.66(5):p. 190.
17. Tersalvi, G., et al., Elevated troponin in patients with coronavirus disease 2019: possible mechanisms. Journal of cardiac failure, 2020. 26(6): p. 470-475.
18. Tao G, Fan YZ, Chen M, Wu XY, Zhang L, Tao H, Wang HR, Wan J, Wang XH, Lu ZB. Cardiovascular implications of fatal outcomes of patients with coronavirus disease 2019 (COVID-19). JAMA Cardiol. 2020;811–818.
19. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;497–506.
20. Na Z, Zhang DY, Wang WL, Li XW, Bo Y, Song JD, Zhao X, Huang BY, Shi WF, Lu RJ, et al.; China Novel Coronavirus Investigating and Research Team. A novel coronavirus from patients with pneumonia in China. N Engl J Med. 2020;727–733.
21. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, et al., Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020;507–513.
22. Ding Y, He L, Zhang Q, Huang Z, Che X, Hou J, Wang H, Shen H, Qiu L, Li Z., et al., Organ distribution of severe acute respiratory syndrome (SARS) associated

coronavirus (SARS-CoV) in SARS patients: implications for pathogenesis and virus transmission pathways. J Pathol. 2004; 622–630.

23. Alhogbani T. Acute myocarditis associated with novel Middle East respiratory syndrome coronavirus. Ann Saudi Med. 2016;78–80.
24. Zhou F, Yu T, Du RH, Fan HG, Liu Y, Liu ZB, Xiang J, Wang YM, Song B, Gu XY, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;1054–1062.
25. Madjid M, Safavi-Naeini P, Solomon SD, Vardeny O. Potential effects of coronaviruses on the cardiovascular system: a review. JAMA Cardiol. 2020;831–840.
26. Inciardi RM, Lupi L, Zaccone G, Italia L, Raffo M, Tomasoni D, Cani DS, Cerini M, Farina D, Gavazzi E, et al. Cardiac involvement in a patient with coronavirus disease 2019 (COVID-19). JAMA Cardiol. 2020;819–882
27. Kuba K, Imai Y, Rao S, Gao H, Guo F, Guan B, Huan Y, Yang P, Zhang Y, Deng W, et al. A crucial role of angiotensin converting enzyme 2 (ACE2) in SARS coronavirus-induced lung injury. Nat Med. 2005;875–879.
28. Oudit GY, Kassiri Z, Jiang C, Liu PP, Poutanen SM, Penninger JM, Butany J. SARS-coronavirus modulation of myocardial ACE2 expression and inflammation in patients with SARS. Eur J Clin Invest. 2009;618–625.
29. Hamming I, Timens W, Bulthuis ML, Lely AT, Navis G, van Goor H. Tissue distribution of ACE2 protein, the functional receptor for SARS coronavirus. A first step in understanding SARS pathogenesis. J Pathol. 2004;631–637
30. Wu C, Zheng M. Single-cell RNA expression profiling shows that ACE2, the putative receptor of Wuhan 2019-nCoV, has significant expression in the nasal, mouth, lung and colon tissues, and tends to be co-expressed with HLA-DRB1 in the four tissues.
31. de Wit E, van Doremalen N, Falzarano D, Munster VJ. SARS and MERS: recent insights into emerging coronaviruses.
32. The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) — China, 2020. China CDC Wkly. 2020;113–122
33. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, Liu L, Shan H, Lei CL, Hui DSC, et al.; China Medical Treatment Expert Group for Covid-19. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med. 2020;1708–1720.