CARDIAC INDICATION OF CORONAVIRUS (COVID-19): A REVIEW

[1*]Sneha kumari,[2]A.Mounika,[3] Ch.M.Maheshwari, [4]J.V.C Sharma,[5] A.V.S.S.S.Gupta

[1*, 3] Department of pharmacy, Joginpally B.R.Pharmacy College, Bhaskar nagar, Yenkapally, Moinabad, JNTUH, Telangana, India. [2, 4] Department of pharmacognosy, Joginpally B.R.Pharmacy College, Faculty of Pharmacy, Bhaskar nagar, Yenkapally, Moinabad, JNTUH, Telangana, India.

[5]Department of pharmacology, Joginpally B.R.Pharmacy College, Faculty of Pharmacy, Bhaskar nagar, Yenkapally, Moinabad, JNTUH,Telangana, India.

Abstract: Intense respiratory disorder Covid 2 (SARS-CoV-2) or COVID-19 contamination is the reason for the continuous worldwide pandemic. Passing's from COVID-19 contaminations are extremely high in patients with cardiovascular infection. Moreover, COVID-19 patients with previous cardiovascular comorbidities are at more serious danger of death. The super cardiovascular intricacies of COVID-19 are myocardial dead tissue, myocarditis, intense myocardial localized necrosis, arrhythmias, cardiovascular breakdown, stroke, and venous thromboembolism. Clinical intercessions dependent on COVID-19 medications have numerous unfavorable cardiovascular impacts. Here, we audit the adequacy of medication related treatments and symptoms of COVID-19 medications.
Index terms -Covid-19,SARS CoV-2,Cardiovascular complication, myocardial infraction, Arrhythmias

I. Introduction

Covid 2019 (COVID-19) is a flow worldwide, arising, pestilence illness brought about by SARS-CoV-2 disease. SARS-CoV-2 is a sort of RNA infection with a trademark envelope and a direct single strand genome, which is unique in relation to intense respiratory condition (SARS) and Middle Eastern respiratory sickness (MERS) disease and hereditary mutation. Coronaviruses are a huge group of innocuous, covered RNA infections, which can influence numerous types of creatures and people. Human Covid can be arranged by their pathogenicity. Types with high pathogenicity incorporate SARS-CoV, MERS-CoV, and the current adaptation of SARS-CoV2. [1] Chronic respiratory infection Covid 2 (SARS-CoV-2) has prompted the most noticeably awful pandemic of this century with Coronavirus 2019 (COVID-19). Initially known as respiratory framework infection, COVID-19 has been found to intervene and influence the cardiovascular framework prompting myocardial harm and cardiovascular and endothelial brokenness particularly with the Angiotensin-changing over compound 2 (ACE-2) receptor. [2] [3] [4] [5] truth be told, heart harm has been noted even external the clinical highlights of respiratory sickness. Then again, respiratory indications are more terrible in patients impacted by COVID-19 with prior coronary illness; notwithstanding, new cardiovascular breakdown is normal in this subset. Indeed, heart harm has been noted even external the clinical highlights of respiratory sickness. Then again, respiratory side effects are more awful in patients impacted by COVID-19 with prior coronary illness; notwithstanding, new cardiovascular breakdown is normal in this clasp. [6] [7] [8] [9]

II. Etiology

In December 2019, instances of uncommon pneumonia were found in Wuhan, China. The original SARS-CoV2 infection has been distinguished as the reason for the new Corona 2019 illness (COVID-19). [2]

III.Epidemiology

3.1 China

Inclusion of heart conditions was noted toward the start of the pandemic in reports from China. An examination of 187 patients treated at Wuhan Hospital between January 23 and February 23, 2020, found that 35% had existing heart issues, for example, hypertension, coronary illness, and cardiomyopathy, and 28% showed myocardial injury demonstrating significant degrees of troponin T. (9). Other Chinese reports observed that the standard degrees of cardiovascular sickness range from 5% to 16%, hypertension from 15% to 31%, cardiovascular infection 11%, and diabetes by 10%. [10]
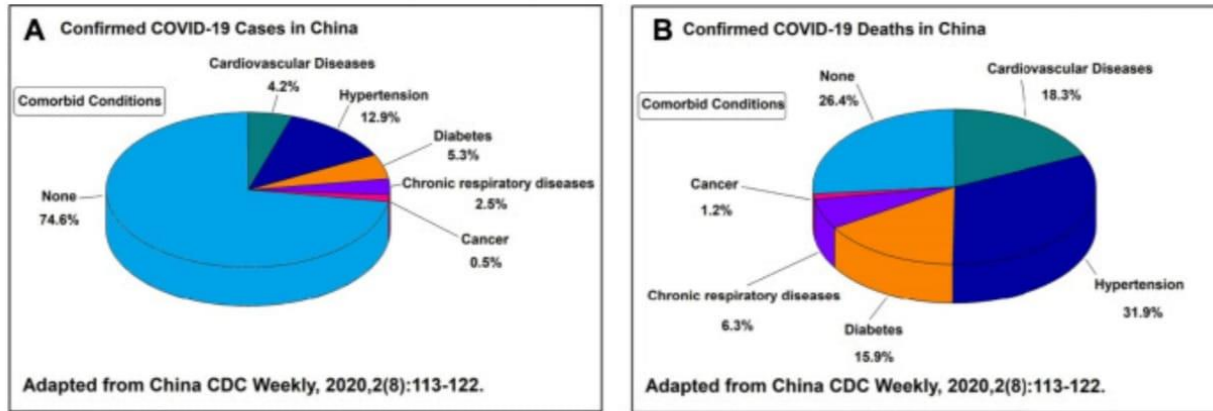
Figure 1: A) Proportion of the Chinese patients and their comorbid conditions that were diagnosed with COVID-19. (B) Proportion of the Chinese patients and their comorbid conditions that died from COVID-19

3.2 World Scenario

Past China, exceptionally high paces of these illnesses have been accounted for. A progression of review cases from Italy detailed outcomes from 1,591 basically sick patients with COVID-19 conceded to the emergency unit): (49% of patients had hypertension, 21% had coronary illness, and 17% % had diabetes. [11] In a New York study between March 2 and April 1, 2020, 1150 grown-ups with COVID-19 were conceded to two clinics; 257 were truly sick. Of these, 82% had something like one constant ailment, most normally hypertension (63%), diabetes (36%), weight (46%), and coronary illness (19%). [12] In a progression of high-hazard instances of 5700 COVID-19 patients conceded to 12 New York clinics; the predominance of hypertension, diabetes, and coronary conduit illness was 57%, 34%, and 11%, separately. [13]
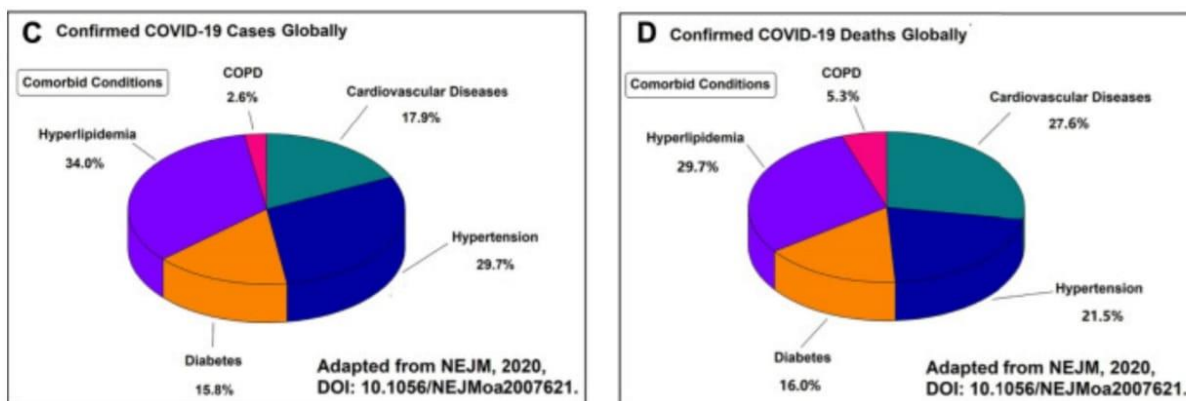
Figure 2: C) Proportion of the global patients and their comorbid conditions that were diagnosed with COVID-19. (D) Proportion of the global patients and their comorbid conditions that died from COVID-19. All the four figures indicate that the major complications of COVID-19 are the cardiovascular related diseases.

IV. Pathophysiology

4.1 ACE2 Receiver

SARS-CoV-2 uses its S-spike to tie to ACE2 receptors as a cell section point. These ACE2 receptors are communicated in type 1 and type 2 pneumocytes and other cell types, including endothelial cells. ACE2 is the contrary controller of the renin-angiotensin-aldosterone framework. Like other Covids, SARS-CoV-2 uses these ACE2 receptors to target explicit respiratory frameworks. [2] [14] [15]

4.2 SARS-CoV-2 and Immune Response

There are two periods of the invulnerable reaction to COVID-19. Stage 1 happens during the hatching period of the illness, in which the invulnerable framework attempts to destroy the infection; in case there is a particular imperfection in this stage, SARS-CoV-2 will spread and cause harm, with serious harm to organs with significant degrees of ACE2 receptors, including lungs, endothelial cells, heart and kidneys. This significant harm prompts stage 2: extreme irritation of the impacted organs. [16]

Diabetes, atherosclerosis, and corpulence, which add to the danger of cardiovascular sickness, debilitate the invulnerable framework. This is related to a negative expectation on COVID-19. [17]

4.3 Cardiovascular Injury Methods in COVID-19

A few sorts of heart harm have been proposed, in light of past investigations of the SARS and MERS scourge and the continuous COVID-19 plague. Part of the reaction to fundamental irritation in serious COVID-19 is the arrival of significant degrees of cytokines (known as cytokine discharge condition) that can harm many tissues, including the vascular endothelium and heart myocyte. [14] [15] [18] [19]

4.4 Cytokine Release Syndrome

Cytokine discharge condition happens in patients with extreme COVID-19 contamination. Numerous proinflammatory cytokines are exceptionally high in extreme cases, including interleukin (IL) - 2, IL-10, IL-6, IL-8, and cancer corruption factor (TNF) - α. [16] [18] Cytokines assume a significant part during contamination (stage 1) and during intense persistent aggravation (stage 2), prompting serious respiratory sorrow (ARDS) and opposite end-stage wounds. [16] [20]

4.5 Direct Injury of Myocardial Cells

SARS-CoV-2 collaborations with ACE2 can cause changes in ACE2 pathways, prompting serious harm to lung, heart, and endothelial cells. Few case reports have shown that SARS-CoV2 might be straightforwardly tainted in the myocardium, causing viral myocarditis. Nonetheless, much of the time, myocardial injury has been demonstrated to be expected to an expanded cardiometabolic necessity related to fundamental contamination and moderate hypoxia brought about by pneumonia or ARDS. [18]

4.6 Intense Coronary Syndrome

The crack of the plaque prompting oak seed coronary condition can bring about foundational irritation and expanded catecholamine levels from the infection. [18] [21] Coronary apoplexy has likewise been recognized as a potential reason for intense coronary disorder in patients with COVID-19. [22]

4.7 Other Possible Ways

Certain meds like corticosteroids, antimicrobials, and immunological specialists might have antagonistic cardio poisonous impacts. Electrolyte issues can happen in any genuine foundational sickness and cause arrhythmias, in which patients with lower coronary illness are at more serious danger. There is some worry about hypokalemia in patients with COVID-19, given the connection of SARS-CoV-2 with the renin-angiotensin-aldosterone framework. Hypokalemia is most popular for expanding the danger of different kinds of arrhythmia. [9] [18]

Figure 3: Main pathway of cardiovascular complications of drugs used to treat Covid-19

DRUG USED IN COVID-19 + SARC-CoV-2	1.DIRECT CARDIACTOXICITY 2.SYSTEMIC INFLAMMATION
	3.PLAQYE RUPTURE AND THROMBOSIS OF CORONARY 4.DISSEMINATED INTRAVASCULAR COAGULATION DUE O SEPSIS
	5.MISMATCH OF MYOCARDIAL SUPPLY AND DEMAND 6.IMBALANCE OF ELECTROLYTES

V. Testing

5.1Blood Investigations

Other research center irregularities have been related to heart inclusion and genuine disease. These incorporate lymphopenia, high lactate dehydrogenase, liver compounds, ferritin, and C-dynamic proteins, prothrombin time, troponin, creatine phosphokinase, serum creatinine, and D - dimer. [23] [24]

5.2 Illustration

Transthoracic echocardiography is suggested for patients with coronary illness, arrhythmia, ECG changes, or cardiomegaly as of late analyzed chest X-beam or chest CT. [25] Cardiac MRI was utilized to distinguish cardiovascular brokenness in COVID-19. [26] [27]

Coronary angiography ought to be performed by the persistent show and provided that demonstrated. [28]

Table 5. 1: Adverse Cardiovascular effects of potential drugs to treat Covid-19

DRUG	MECHANISM	ADVERSE EFFECTS
Lopinavir/Ritonavir	Protease inhibitor, inhibits 3CLpro	Hypertension prolonged P-R and Q-T interval Severe conduction disorder
Remdesivir	Protease inhibitor, inhibits SARS-CoV-2RNA dependent RNA polymerase	Hypotension Bradycardia QTc prolongation
Interferon alpha	Protease inhibitor, viral load reduction through inhibition of replication	Ischemic Cardiomyopathy Arrhythmias Hypertension Hypotension
Ribavirin	Viral load reduction through inhibition of replication	Bradycardia Cardiac dysfunction Anemia Hypomagnesaemia Mitochondrial toxicity

| Chloroquine	Viral load reduction through inhibition of replication	Myocardial suppression irreversible cardiomyopathy Atrioventricular Block Hypokalemia Hypotension
Baricitinib	Protease inhibitor , inhibits Janus kinase	Hyperglycemia Infections Thromboembolic events
Arbidol	Protease inhibitor, inhibits glycoprotein	Nausea Diarrhea Dizziness Bradycardia
Dexamethose	Combat Cytokine storm by limiting the production of damaging effect of the cytokines	Arrhythmias Headache Agitation Dizziness Increased appetite
Toclizumab	Inhibits the activity of IL-6 receptor, blocks the cytokine strom,caused by IL-6 pathway	Cardiomyopathy Liver injury
Fapiravir	Inhibiting RNA synthetase	Hypotension Arrhythmia

VI. Case study
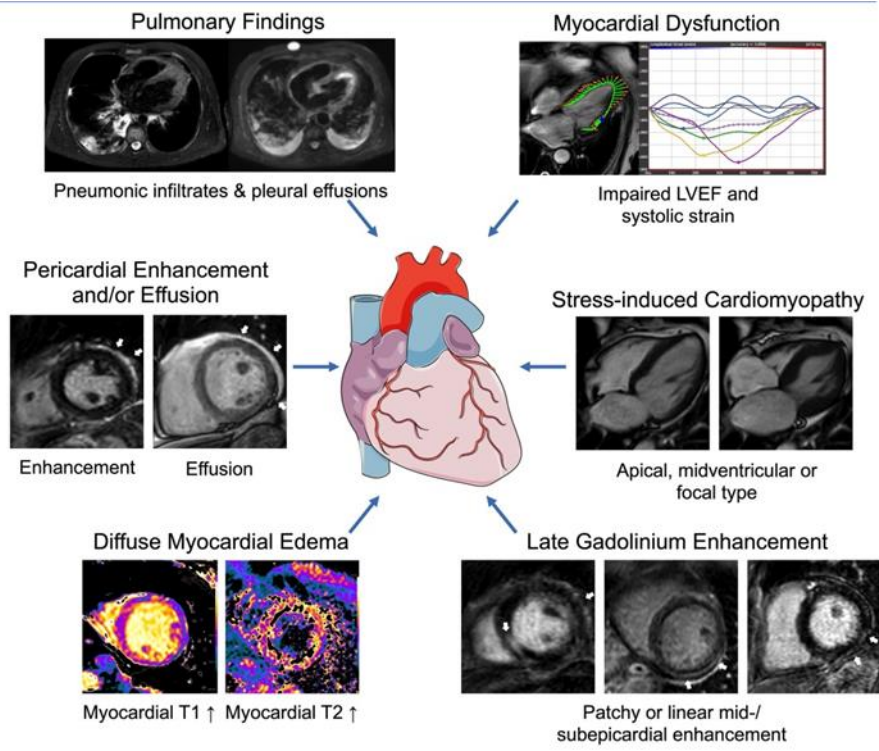
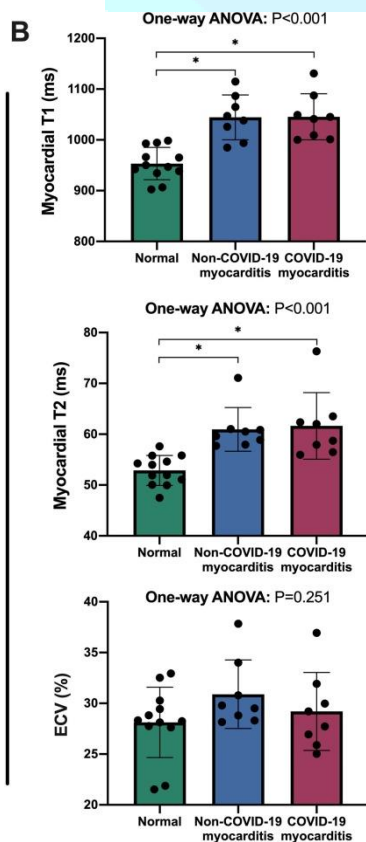**Figure 4 – Cardiac MRI in suspected acute covid 19 myocarditis**

Figure 5- Column graphs with individual plotted values show distribution of quantitative myocardial MRI parameters in healthy participants and in participants with suspected acute non–COVID-19 and COVID-19 myocarditis.(51)

We identified an example of myocardial edema that spread to members with manifestations of COVID-19 disease and suspected myocarditis. Myocardial edema influences myocardial capacity and might be a sign of broad irritation because of the insusceptible framework, direct myocardial injury of SARS-CoV-2, or vascular spillage because of endothelial harm. Strangely, the quantity of LGE injuries, as an indication of myocyte rot, was lower in members with COVID-19 myocarditis contrasted and members with intense non-COVID-19 myocarditis, which is basically brought about via cardio tropic infections. This outcome proposes that the path mechanism of myocardial localized necrosis might be unique in relation to SARS-CoV-2 and is logical depending on the connection of a wide assortment of the cardiovascular framework. Additionally, we noticed examples of stress-incited cardiomyopathy as an option in contrast to myocardial injury in members with COVID-19. Since the event of myocardial injury and the qualities of stress-instigated cardiomyopathy are related to the deadly result of COVID-19, the checked changes in cardiovascular changes are especially intriguing.

VII. Treatment / Management

5.1 Complete Cardiac Care for Patients COVID-19

Cardiac care needs to be developed for COVID-19 patients for the purpose of early detection and management of cardiovascular disease for the purpose of diagnostic and preventive measures to prevent or reduce COVID-19 exposure. [29] As Bonow et al. to put it bluntly, the message to patients should be clear that urgent care should be sought if there are warning signs of a heart attack. Wearing a mask, walking away from the body is still as important as ever. At the same time, doctors and researchers are finding the best procedures for COVID-19-related cardiovascular disease. [30]

5.2 ACE inhibitors (ACEI) / Angiotensin Receptor Blockers (ARB)

In early 2020, controversy arose over the safe use of these drugs for COVID-19 patients. The current consensus is in line with the continued use of these drugs. [31] [32] The BRACE CORONA trial was introduced at ESC Congress 2020, which found no significant difference in the number of days of life and hospitalization out of 30 days between subjects receiving continuous ACEI / ARB and hospitalization due to COVID-19 compared and those who had been on medication for some time. Paused. [33] Five common categories of safe antihypertensive drugs are safe for COVID-19 patients and do not increase the risk of infection. [34]

5.3 Remdesivir

Remdesivir is an antiretroviral drug (RNA polymerase inhibitor) used to treat COVID-19. A multicenter, double-blind RCT from China studied Remdesivir for adult patients hospitalized due to severe COVID-19. Studies have shown a decrease in clinical improvement in the treatment group compared with controls, but the difference was not significant. (35) The subsequent case, sponsored by the US National Institute of Allergy and Infectious Disease, examined 1063 patients in COVID-19 hospitals in a retrospective study. Results published in the New England Journal of Medicine showed a quick recovery time for patients receiving remdesivir vs. placebo. [36]

The US Food and Drug Administration (FDA) have approved the approval of emergency use of remdesivir to all hospitalized patients with COVID-19. To date, no cardiovascular side effects have been reported with Remdesivir, although this may be reflected in future use during the COVID-19 epidemic.

5.4 Hydroxychloroquine and Chloroquine

Hydroxychloroquine was introduced as a potential treatment for COVID-19 patients based on an open label, a single-group study from France. [37] However, clinical trials of COVID-19 patients in hospitals conducted at a major New York City medical center found no significant benefit from hydroxychloroquine. [38] The use of hydroxychloroquine alone or hydroxychloroquine and azithromycin did not improve the combined result of intubation or death.

Chloroquine has been known to cause atrioventricular block and long QTc blocks, especially when combined with azithromycin. [39] The lack of benefits observed in clinical trials and the potential for adverse cardiac outcomes have led the FDA to withdraw its urgent approval of the use of hydroxychloroquine and chloroquine in patients on COVID-19.

5.5 Azithromycin

Azithromycin was commonly used in combination with hydroxychloroquine as an early treatment for the epidemic. However, a few studies of this combination did not show any clinical benefit. [40] [41] Azithromycin is a macrolide and is known to prolong the QTc interval. Combining azithromycin with chloroquine or hydroxychloroquine increases QTc expansion and potentially increases the risk of torsade de points. Lack of clinical benefit and strength of cardiac arrhythmias have discouraged clinicians from using azithromycin in COVID-19. [42]

5.6 Vaccination

The SARS-CoV-2 genetic sequence was published in January 2020, and since then, teams of researchers around the world have been working hard to develop a vaccine for the SARS-CoV-2 vaccine. More than 90 vaccines are being developed at this time. [43] [44] Vaccination has begun in various countries. MRNA-based vaccines developed by Pfizer and Moderna have been approved for emergency use (EUA) by the US Food and Drug Administration (FDA). Most health workers have already received these vaccines.

Immune thrombotic thrombocytopenia developed after the ChAdOx1nCov-19 vaccine was reported as a rare complication that arose in a few cases. Method of thrombocytopenia similar to heparin-induced thrombocytopenia. [45]

No significant heart problems have been reported with any of the vaccines so far.

VIII. Prognosis

The majority of patients (80%) will develop a mild form of the disease. A serious case of the disease occurs in approximately 15 million patients who need hospitalization and the most serious form occurs in about 5% of patients who need intensive care. The present mortality rate is between 2% to 5% of all patients with COVID-19 but is much higher in patients who require less oxygen intake. The leading cause of death in COVID-19 is severe respiratory depression (ARDS); however, there are other important aspects of organ involvement, including the cardiovascular system and shock. [2] [14] [15] The presence of chronic heart disease or heart involvement leads to a higher mortality rate compared to patients without heart disease. [8] [46]

In the COVID-19 epidemic, very few heart patients have been to clinics or hospitals for fear of contracting the virus. In contrast, heart patients despite the fact that SARS-CoV-2 infection requires immediate diagnosis and management, especially with this disease as resources and staff is often at risk. [47] [48]

The predicted value of cardiovascular disease was fully demonstrated in a group of 191 patients where 30% had high blood pressure and made up 48% of underweight people, while 8% had cardiovascular disease and accounted for 13% of underweight people. [24] In a report on 44672 confirmed COVID-19 cases from the China Center for Disease Control and Prevention, the mortality rate was 2.3% for the whole group but significantly higher in patients with hypertension (6%), diabetes (7%)), or heart disease (11%). [49]

IX. Improving the Outcomes of the Health Care Team

SARS-CoV-2 infection has been reported to be complicated by heart failure. Existing heart disease puts the disease at risk and increases the risk of heart disease. Early detection of cardiovascular disease by clinical and laboratory parameters and treatment is very important. Clinical trials are ongoing, and more research will follow to diagnose and treat the disease, which will guide physicians in treatment and policymakers to set guidelines for better management of COVID-19 cardiovascular features.

X. References

1.Weiss SR, Navas-Martin S. Coronavirus pathogenesis and the emerging pathogen severe acute respiratory syndrome coronavirus. Microbial Mol Biol Rev. 2005 Dec;69(4):635-64. (PMC free article) (PubMed)

2.Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, Wang B, Xiang H, Cheng Z, Xiong Y, Zhao Y, Li Y, Wang X, Peng Z. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. JAMA. 2020 Mar 17;323(11):1061-1069. (PMC free article) (PubMed)

3.Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T, Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Gao H, Guo L, Xie J, Wang G, Jiang R, Gao Z, Jin Q, Wang J, Cao B. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020 Feb 15;395(10223):497-506. (PMC free article) (PubMed)

4.Hoffmann M, Kleine-Weber H, Schroeder S, Krüger N, Herrler T, Erichsen S, Schiergens TS, Herrler G, Wu NH, Nitsche A, Müller MA, Drosten C, Pöhlmann S. SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor. Cell. 2020 Apr 16;181(2):271-280.e8. (PMC free article) (PubMed)

5.Tikellis C, Thomas MC. Angiotensin-Converting Enzyme 2 (ACE2) Is a Key Modulator of the Renin Angiotensin System in Health and Disease. Int J Pept. 2012;2012:256294. (PMC free article) (PubMed)

6.Inciardi RM, Lupi L, Zaccone G, Italia L, Raffo M, Tomasoni D, Cani DS, Cerini M, Farina D, Gavazzi E, Maroldi R, Adamo M, Ammirati E, Sinagra G, Lombardi CM, Metra M. Cardiac Involvement in a Patient With Coronavirus Disease 2019 (COVID-19). JAMA Cardiol. 2020 Jul 01;5(7):819-824. (PMC free article) (PubMed)

7.Badawi A, Ryoo SG. Prevalence of comorbidities in the Middle East respiratory syndrome coronavirus (MERS-CoV): a systematic review and meta-analysis. Int J Infect Dis. 2016 Aug;49:129-33. (PMC free article) (PubMed)

8.Li B, Yang J, Zhao F, Zhi L, Wang X, Liu L, Bi Z, Zhao Y. Prevalence and impact of cardiovascular metabolic diseases on COVID-19 in China. Clin Res Cardiol. 2020 May;109(5):531-538. (PMC free article) (PubMed)

9.Bansal M. Cardiovascular disease and COVID-19. Diabetes MetabSyndr. 2020 May - Jun;14(3):247-250. (PMC free article) (PubMed)

10.Shi S, Qin M, Shen B, Cai Y, Liu T, Yang F, Gong W, Liu X, Liang J, Zhao Q, Huang H, Yang B, Huang C. Association of Cardiac Injury With Mortality in Hospitalized Patients With COVID-19 in Wuhan, China. JAMA Cardiol. 2020 Jul 01;5(7):802-810. (PMC free article) (PubMed)

11.Grasselli G, Zangrillo A, Zanella A, Antonelli M, Cabrini L, Castelli A, Cereda D, Coluccello A, Foti G, Fumagalli R, Iotti G, Latronico N, Lorini L, Merler S, Natalini G, Piatti A, Ranieri MV, Scandroglio AM, Storti E, Cecconi M, Pesenti A., COVID-19 Lombardy ICU Network. Baseline Characteristics and Outcomes of 1591 Patients Infected With SARS-CoV-2 Admitted to ICUs of the Lombardy Region, Italy. JAMA. 2020 Apr 28;323(16):1574-1581. (PMC free article) (PubMed)

12.Cummings MJ, Baldwin MR, Abrams D, Jacobson SD, Meyer BJ, Balough EM, Aaron JG, Claassen J, Rabbani LE, Hastie J, Hochman BR, Salazar-Schicchi J, Yip NH, Brodie D, O'Donnell MR. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. Lancet. 2020 Jun 06;395(10239):1763-1770. (PMC free article) (PubMed)

13.Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, the Northwell COVID-19 Research Consortium. Barnaby DP, Becker LB, Chelico JD, Cohen SL, Cookingham J, Coppa K, Diefenbach MA, Dominello AJ, Duer-Hefele J, Falzon L, Gitlin J, Hajizadeh N, Harvin TG, Hirschwerk DA, Kim EJ, Kozel ZM, Marrast LM, Mogavero JN, Osorio GA, Qiu M, Zanos TP. Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. JAMA. 2020 May 26;323(20):2052-2059. (PMC free article) (PubMed)

14.Xu Z, Shi L, Wang Y, Zhang J, Huang L, Zhang C, Liu S, Zhao P, Liu H, Zhu L, Tai Y, Bai C, Gao T, Song J, Xia P, Dong J, Zhao J, Wang FS. Pathological findings of COVID-19 associated with acute respiratory distress syndrome. Lancet Respir Med. 2020 Apr;8(4):420-422. (PMC free article) (PubMed)

15.Zheng YY, Ma YT, Zhang JY, Xie X. COVID-19 and the cardiovascular system. Nat Rev Cardiol. 2020 May;17(5):259-260. (PMC free article) (PubMed)

16.Shi Y, Wang Y, Shao C, Huang J, Gan J, Huang X, Bucci E, Piacentini M, Ippolito G, Melino G. COVID-19 infection: the perspectives on immune responses. Cell Death Differ. 2020 May;27(5):1451-1454. (PMC free article) (PubMed)

17.Driggin E, Madhavan MV, Bikdeli B, Chuich T, Laracy J, Biondi-Zoccai G, Brown TS, Der Nigoghossian C, Zidar DA, Haythe J, Brodie D, Beckman JA, Kirtane AJ, Stone GW, Krumholz HM, Parikh SA. Cardiovascular Considerations for Patients, Health Care Workers, and Health Systems During the COVID-19 Pandemic. J Am CollCardiol. 2020 May 12;75(18):2352-2371. (PMC free article) (PubMed)

18.Xiong TY, Redwood S, Prendergast B, Chen M. Coronaviruses and the cardiovascular system: acute and long-term implications. Eur Heart J. 2020 May 14;41(19):1798-1800. (PMC free article) (PubMed)

19.Clerkin KJ, Fried JA, Raikhelkar J, Sayer G, Griffin JM, Masoumi A, Jain SS, Burkhoff D, Kumaraiah D, Rabbani L, Schwartz A, Uriel N. COVID-19 and Cardiovascular Disease. Circulation. 2020 May 19;141(20):1648-1655. (PubMed)

20.Qin C, Zhou L, Hu Z, Zhang S, Yang S, Tao Y, Xie C, Ma K, Shang K, Wang W, Tian DS. Dysregulation of Immune Response in Patients With Coronavirus 2019 (COVID-19) in Wuhan, China. Clin Infect Dis. 2020 Jul 28;71(15):762-768. (PMC free article) (PubMed)

21.Schoenhagen P, Tuzcu EM, Ellis SG. Plaque vulnerability, plaque rupture, and acute coronary syndromes: (multi)-focal manifestation of a systemic disease process. Circulation. 2002 Aug 13;106(7):760-2. (PubMed)

22.Dominguez-Erquicia P, Dobarro D, Raposeiras-Roubín S, Bastos-Fernandez G, Iñiguez-Romo A. Multivessel coronary thrombosis in a patient with COVID-19 pneumonia. Eur Heart J. 2020 Jun 07;41(22):2132. (PMC free article) (PubMed)

23.Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T, Zhang X, Zhang L. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020 Feb 15;395(10223):507-513. (PMC free article) (PubMed)

24.Goyal P, Choi JJ, Pinheiro LC, Schenck EJ, Chen R, Jabri A, Satlin MJ, Campion TR, Nahid M, Ringel JB, Hoffman KL, Alshak MN, Li HA, Wehmeyer GT, Rajan M, Reshetnyak E, Hupert N, Horn EM, Martinez FJ, Gulick RM, Safford MM. Clinical Characteristics of Covid-19 in New York City. N Engl J Med. 2020 Jun 11;382(24):2372-2374. (PMC free article) (PubMed)

25.Hung J, Abraham TP, Cohen MS, Main ML, Mitchell C, Rigolin VH, Swaminathan M. ASE Statement on the Reintroduction of Echocardiographic Services during the COVID-19 Pandemic. J Am SocEchocardiogr. 2020 Aug;33(8):1034-1039. (PMC free article) (PubMed)

26.Stogiannos N, Fotopoulos D, Woznitza N, Malamateniou C. COVID-19 in the radiology department: What radiographers need to know. Radiography (Lond). 2020 Aug;26(3):254-263. (PMC free article) (PubMed)

27.Han Y, Chen T, Bryant J, Bucciarelli-Ducci C, Dyke C, Elliott MD, Ferrari VA, Friedrich MG, Lawton C, Manning WJ, Ordovas K, Plein S, Powell AJ, Raman SV, Carr J. Society for Cardiovascular Magnetic Resonance (SCMR) guidance for the practice of cardiovascular magnetic resonance during the COVID-19 pandemic. J CardiovascMagnReson. 2020 Apr 27;22(1):26. (PMC free article) (PubMed)

28.Garg N, McClafferty B, Ramgobin D, Golamari R, Jain R, Jain R. Cardiology and COVID-19: do we have sufficient information? Future Cardiol. 2021 Jul;17(4):705-711. (PMC free article) (PubMed)

29.Lakkireddy DR, Chung MK, Gopinathannair R, Patton KK, Gluckman TJ, Turagam M, Cheung JW, Patel P, Sotomonte J, Lampert R, Han JK, Rajagopalan B, Eckhardt L, Joglar J, Sandau KE, Olshansky B, Wan E, Noseworthy PA, Leal M, Kaufman E, Gutierrez A, Marine JE, Wang PJ, Russo AM. Guidance for cardiac electrophysiology during the COVID-19 pandemic from the Heart Rhythm Society COVID-19 Task Force; Electrophysiology Section of the American College of Cardiology; and the Electrocardiography and Arrhythmias Committee of the Council on Clinical Cardiology, American Heart Association. Heart Rhythm. 2020 Sep;17(9):e233-e241. (PMC free article) (PubMed)

30.Bonow RO, O'Gara PT, Yancy CW. Cardiology and COVID-19. JAMA. 2020 Sep 22;324(12):1131-1132. (PubMed)

31.Sommerstein R, Kochen MM, Messerli FH, Gräni C. Coronavirus Disease 2019 (COVID-19): Do Angiotensin-Converting Enzyme Inhibitors/Angiotensin Receptor Blockers Have a Biphasic Effect? J Am Heart Assoc. 2020 Apr 07;9(7):e016509. (PMC free article) (PubMed)

32.Bozkurt B, Kovacs R, Harrington B. Joint HFSA/ACC/AHA Statement Addresses Concerns Re: Using RAAS Antagonists in COVID-19. J Card Fail. 2020 May;26(5):370. (PMC free article) (PubMed)

33.Lopes RD, Macedo AVS, de Barros E Silva PGM, Moll-Bernardes RJ, Feldman A, D'Andréa Saba Arruda G, de Souza AS, de Albuquerque DC, Mazza L, Santos MF, Salvador NZ, Gibson CM, Granger CB, Alexander JH, de Souza OF., BRACE CORONA investigators. Continuing versus suspending angiotensin-converting enzyme inhibitors and angiotensin receptor blockers: Impact on adverse outcomes in hospitalized patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)--The BRACE CORONA Trial. Am Heart J. 2020 Aug;226:49-59. (PMC free article) (PubMed)

34.Reynolds HR, Adhikari S, Pulgarin C, Troxel AB, Iturrate E, Johnson SB, Hausvater A, Newman JD, Berger JS, Bangalore S, Katz SD, Fishman GI, Kunichoff D, Chen Y, Ogedegbe G, Hochman JS. Renin-Angiotensin-Aldosterone System Inhibitors and Risk of Covid-19. N Engl J Med. 2020 Jun 18;382(25):2441-2448. (PMC free article) (PubMed)

35.Wang Y, Zhang D, Du G, Du R, Zhao J, Jin Y, Fu S, Gao L, Cheng Z, Lu Q, Hu Y, Luo G, Wang K, Lu Y, Li H, Wang S, Ruan S, Yang C, Mei C, Wang Y, Ding D, Wu F, Tang X, Ye X, Ye Y, Liu B, Yang J, Yin W, Wang A, Fan G, Zhou F, Liu Z, Gu X, Xu J, Shang L, Zhang Y, Cao L, Guo T, Wan Y, Qin H, Jiang Y, Jaki T, Hayden FG, Horby PW, Cao B, Wang C. Remdesivir in adults with severe COVID-19: a randomised, double-blind, placebo-controlled, multicentre trial. Lancet. 2020 May 16;395(10236):1569-1578. (PMC free article) (PubMed)

36.Beigel JH, Tomashek KM, Dodd LE, Mehta AK, Zingman BS, Kalil AC, Hohmann E, Chu HY, Luetkemeyer A, Kline S, Lopez de Castilla D, Finberg RW, Dierberg K, Tapson V, Hsieh L, Patterson TF, Paredes R, Sweeney DA, Short WR, Touloumi G, Lye DC,

Ohmagari N, Oh MD, Ruiz-Palacios GM, Benfield T, Fätkenheuer G, Kortepeter MG, Atmar RL, Creech CB, Lundgren J, Babiker AG, Pett S, Neaton JD, Burgess TH, Bonnett T, Green M, Makowski M, Osinusi A, Nayak S, Lane HC., ACTT-1 Study Group Members. Remdesivir for the Treatment of Covid-19 - Final Report. N Engl J Med. 2020 Nov 05;383(19):1813-1826. (PMC free article) (PubMed)

37.Gautret P, Lagier JC, Parola P, Hoang VT, Meddeb L, Mailhe M, Doudier B, Courjon J, Giordanengo V, Vieira VE, TissotDupont H, Honoré S, Colson P, Chabrière E, La Scola B, Rolain JM, Brouqui P, Raoult D. Hydroxychloroquine and azithromycin as a treatment of COVID-19: results of an open-label non-randomized clinical trial. Int J Antimicrob Agents. 2020 Jul;56(1):105949. (PMC free article) (PubMed)

38.Geleris J, Sun Y, Platt J, Zucker J, Baldwin M, Hripcsak G, Labella A, Manson DK, Kubin C, Barr RG, Sobieszczyk ME, Schluger NW. Observational Study of Hydroxychloroquine in Hospitalized Patients with Covid-19. N Engl J Med. 2020 Jun 18;382(25):2411-2418. (PMC free article) (PubMed)

39.Rosenberg ES, Dufort EM, Udo T, Wilberschied LA, Kumar J, Tesoriero J, Weinberg P, Kirkwood J, Muse A, DeHovitz J, Blog DS, Hutton B, Holtgrave DR, Zucker HA. Association of Treatment With Hydroxychloroquine or Azithromycin With In-Hospital Mortality in Patients With COVID-19 in New York State. JAMA. 2020 Jun 23;323(24):2493-2502. (PMC free article) (PubMed)

40.Cavalcanti AB, Zampieri FG, Rosa RG, Azevedo LCP, Veiga VC, Avezum A, Damiani LP, Marcadenti A, Kawano-Dourado L, Lisboa T, Junqueira DLM, de Barros E Silva PGM, Tramujas L, Abreu-Silva EO, Laranjeira LN, Soares AT, Echenique LS, Pereira AJ, Freitas FGR, Gebara OCE, Dantas VCS, Furtado RHM, Milan EP, Golin NA, Cardoso FF, Maia IS, Hoffmann Filho CR, Kormann APM, Amazonas RB, Bocchi de Oliveira MF, Serpa-Neto A, Falavigna M, Lopes RD, Machado FR, Berwanger O., Coalition Covid-19 Brazil I Investigators. Hydroxychloroquine with or without Azithromycin in Mild-to-Moderate Covid-19. N Engl J Med. 2020 Nov 19;383(21):2041-2052. (PMC free article) (PubMed)

41Borba MGS, Val FFA, Sampaio VS, Alexandre MAA, Melo GC, Brito M, Mourão MPG, Brito-Sousa JD, Baía-da-Silva D, Guerra MVF, Hajjar LA, Pinto RC, Balieiro AAS, Pacheco AGF, Santos JDO, Naveca FG, Xavier MS, Siqueira AM, Schwarzbold A, Croda J, Nogueira ML, Romero GAS, Bassat Q, Fontes CJ, Albuquerque BC, Daniel-Ribeiro CT, Monteiro WM, Lacerda MVG., CloroCovid-19 Team. Effect of High vs Low Doses of Chloroquine Diphosphate as Adjunctive Therapy for Patients Hospitalized With Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Infection: A Randomized Clinical Trial. JAMA Netw Open. 2020 Apr 24;3(4):e208857. (PubMed)

42.Fiolet T, Guihur A, Rebeaud ME, Mulot M, Peiffer-Smadja N, Mahamat-Saleh Y. Effect of hydroxychloroquine with or without azithromycin on the mortality of coronavirus disease 2019 (COVID-19) patients: a systematic review and meta-analysis. ClinMicrobiol Infect. 2021 Jan;27(1):19-27. (PMC free article) (PubMed)

43.Lurie N, Saville M, Hatchett R, Halton J. Developing Covid-19 Vaccines at Pandemic Speed. N Engl J Med. 2020 May 21;382(21):1969-1973. (PubMed)

44.Thanh Le T, Andreadakis Z, Kumar A, Gómez Román R, Tollefsen S, Saville M, Mayhew S. The COVID-19 vaccine development landscape.Nat Rev Drug Discov. 2020 May;19(5):305-306. (PubMed)

45.Greinacher A, Thiele T, Warkentin TE, Weisser K, Kyrle PA, Eichinger S. Thrombotic Thrombocytopenia after ChAdOx1 nCov-19 Vaccination. N Engl J Med. 2021 Jun 03;384(22):2092-2101. (PMC free article) (PubMed)

46.Gao C, Wang Y, Gu X, Shen X, Zhou D, Zhou S, Huang JA, Cao B, Guo Q., Community-Acquired Pneumonia–China Network. Association Between Cardiac Injury and Mortality in Hospitalized Patients Infected With Avian Influenza A (H7N9) Virus. Crit Care Med. 2020 Apr;48(4):451-458. (PMC free article) (PubMed)

47.De Rosa S, Spaccarotella C, Basso C, Calabrò MP, Curcio A, Filardi PP, Mancone M, Mercuro G, Muscoli S, Nodari S, Pedrinelli R, Sinagra G, Indolfi C., SocietàItaliana di Cardiologia and the CCU Academy investigators group. Reduction of hospitalizations for myocardial infarction in Italy in the COVID-19 era.Eur Heart J. 2020 Jun 07;41(22):2083-2088. (PMC free article) (PubMed)

48.De Filippo O, D'Ascenzo F, Angelini F, Bocchino PP, Conrotto F, Saglietto A, Secco GG, Campo G, Gallone G, Verardi R, Gaido L, Iannaccone M, Galvani M, Ugo F, Barbero U, Infantino V, Olivotti L, Mennuni M, Gili S, Infusino F, Vercellino M, Zucchetti O, Casella G, Giammaria M, Boccuzzi G, Tolomeo P, Doronzo B, Senatore G, GrossoMarra W, Rognoni A, Trabattoni D, Franchin L, Borin A, Bruno F, Galluzzo A, Gambino A, Nicolino A, TruffaGiachet A, Sardella G, Fedele F, Monticone S, Montefusco A, Omedè P, Pennone M, Patti G, Mancone M, De Ferrari GM. Reduced Rate of Hospital Admissions for ACS during Covid-19 Outbreak in Northern Italy. N Engl J Med. 2020 Jul 02;383(1):88-89. (PMC free article) (PubMed)

49.Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA. 2020 Apr 07;323(13):1239-1242. (PubMed)

50.Prasan Kumar Sahoo,Hiren Kumar Thakkar,Wen-Yen Lin,Ming-Yih Lee-On the Design of an Efficient Cardiac Health Monitoring System Through Combined Analysis of ECG and SCG Signals-Jan 2018

51.Julian A. Luetkens , Alexander Isaak, Can Öztürk, NarineMesropyan, MalteMonin, Stefan Schlabe, MatthäusReinert, Anton Faron, Annkristin Heine, Markus Velten, Darius Dabir, ChristophBoesecke, Christian P. Strassburg, Ulrike Attenberger, Sebastian Zimmer, Georg D. Duerr, Jacob Natterm-Cardiac MRI in Suspected Acute COVID-19 Myocarditis