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Case Report

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Pulmonary Disorder in A Patient Recovering from Coronavirus Disease 2019 In Cardiac Surgery: Case Report and Review

Motahareh Ghodrati[1]*, Abdollah Amini[2] and Omid Imani[2]

Abstract

COVID-19 patients show a range of disturbance, the most significant of which is an acute respiratory syndrome. 17% -29% of them indicated more severe complications of pulmonary disorders including pneumonia and Acute Respiratory Distress Syndrome (ARDS). Preliminary studies have reported an increase in inflammatory mediators and cytokines (cytokine storm) in patients with COVID-19. A Cardiopulmonary Bypass (CPB) alone triggers a potent stimulant to release of inflammatory response throughout the body. The synergistic effect of COVID-19 and CPB development postoperative risks in cardiac surgery patients. The patient was a 53-year-old man with coronary artery disease. After the end of the CPB observed pulmonary dysfunction and decreased Partial pressure of oxygen (PO2) and O2 Saturation (O2 Sat) in Arterial Blood Gas (ABG). In Chest CT, the patient's previous pulmonary lesions were exacerbated after surgery, and pneumonia was diagnosed based on the opinion of an infectious disease specialist.

Keywords

Cardiac Surgery; COVID-19; Alcoholism; Cardiopulmonary bypass; Pulmonary Disorder.

Introduction

Effects of COVID-19 on pulmonary and inflammatory system

As the coronavirus disease 2019 (COVID-19) pandemic has spread around the world; there has been growing recognition that persons with underlying increased cardiovascular risk may be disproportionately affected [1-3]. COVID-19 is approximately 80% similar to the SARS and the causative agent of COVID-19 attacks host cells by binding to the angiotensin-converting enzyme 2 (ACE2) receptor [1]. ACE2 is a membrane-bound monocarboxypeptidase organize ubiquitously in humans and represented predominantly in heart, intestine, kidney, immune systems and pulmonary alveolar (type II) cells [4,5]. Respiratory failure from Acute Respiratory Distress Syndrome (ARDS) is the leading reason of mortality in COVID-19 infection patients [2]. Severe disease onset might result in death due to massive alveolar damage and progressive respiratory failure [6,7]. An initial prospective analysis in Wuhan revealed bilateral lung opacities on 40 of 41 (98%) chest CTs in infected patients and described lobular and subsegmental region of consolidation as the most typical detection [6]. Other investigators examined chest CTs in 21 infected patients and found high rates of ground-glass opacities and consolidation, sometimes with a rounded morphology and peripheral lung distribution [8].

Moreover, accumulating evidence offers that a subgroup of patients with severe COVID-19 might have a cytokine storm syndrome [2]. Secondary hemophagocytic lymph histiocytosis (sHLH) is an under-recognized, hyperinflammatory syndrome characterized by a fulminant and fatal hypercytokinaemia with multiorgan failure.4 Main features of sHLH include unremitting fever, cytopenia's, and hyperferritinaemia; pulmonary involvement (including ARDS) occurs in approximately 50% of patients [8]. At this point, significant lymphopenia is revealed. At the time of admission, the majority of patients demonstrated lymphocytopenia (83.2%), thrombocytopenia (36.2%), and leukopenia (33.7%) [6]. It represented a significant association between lymphopenia and acute respiratory distress syndrome (ARDS) [7]. The enhancement risk of ARDS was significantly associated with a rise in neutrophil and a decrease in lymphocyte [7-10].

Effects of CPB on the pulmonary and inflammatory system

CPB creates an inflammatory response throughout the body. In the most severe form of this reaction, a range of lesions may occur, including dysfunction of the lung, kidney, intestine, brain, myocardium, coagulation and hemolysis disorders, fever, increased susceptibility to infection, leukocytosis. This syndrome is called "SIRS after bypass". Factors such as nonpulsatile flow, share stress, cardiotomy suction (internal vent types), ischemia and reperfusion, hypothermia, relative anemia, and anticoagulants play an important role in stimulating tissue damage and inflammatory response. This response may keep after the off CPB for a long time, and depending on the severity of the inflammatory response, it may have a wide range of adverse clinical consequences [9].

Pulmonary function is impaired in patients after CPB, ranging from microscopic atelectasis to acute respiratory distress syndrome, and therefore oxygenation and mechanical ventilation in patients is challenging. Several factors can be involved in pulmonary dysfunction, including atelectasis, plural opening, pulmonary compliance disorder, and systemic inflammatory response. A significant proportion of deaths after heart surgery are from Acute Lung Injury (ALI). Anaphylatoxins and complement activation, activation of neutrophils, cytokines, arsenic acid metabolites, and impaired pulmonary metabolism are some of the causes of ALI. Activated neutrophils migrate to the inflammatory and ischemic areas during CPB and release proteolytic enzymes and cytotoxins, which directly damage the lungs and increase pulmonary permeability. Finally, it is associated with pulmonary insufficiency after CPB [9].

Case report

Background

A 53-year-old man with a history of hypertension, smoker,

***Corresponding author:** Dr. Motahareh Ghodrati, School of Paramedical Science, Shahid Beheshti Educational hospital, Qom University of Medical Sciences. Qom, Iran, Postcode: 3713649373. Phone: 09355975983, Tel: 025 3612 2000, E-mail: m.ghodrati87@gmail.com

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alcoholism, right bundle branch block, Chronic Kidney Disease (CKD), thyroid nodule, gallstone without stenosis, Hepatitis B Surface (HBS), fatty liver (grade 1) and myocardial infarction three years ago was admitted to hospital for Further investigation suspicious SARS-CoV-2 infection at April 2020. Coronavirus conventional Polymerase Chain Reaction (PCR) assay for the throat swab sample based on the COVID-19 acid amplifying kids of novel coronavirus (2019-nCoV) Real-Time-PCR kit was sent to the laboratory. The result of the RT-PCR test was positive. Combination therapy was started with multiple medications such as azithromycin, corticosteroids, hydroxyzine therapy by infectious disease specialists. After his symptoms were relieved, he discharges from the hospital. The laboratory tests showed the results: troponin 0.78 mg/l, Creatine Kinase-MB (CK-MB) 30 ng/l, Erythrocyte Sedimentation Rate (ESR) 59 mm/hr (Table 1).

Two weeks later, he admitted to the emergency department with chest pain and dyspnea. In the emergency department, transthoracic echocardiography and angiography were performed and obstruction on coronary arteries (left main, Left Anterior Descending Artery (LAD), Diagonal Branches 1 (D1), Diagonal Branches 2 (D2), Posterior Descending Artery (PDA) as a reasons for chest pain and dyspnea were recognized. He had ejection fraction (EF) 50% and mild Mitral Regurgitation (MR). According to the TIMI (The Thrombolysis In Myocardial Infarction) score of 6, the maximum waiting time score (Risk Score) of 8, frequent chest pain, the rise of troponin, ECG changes, Arrhythmia (Atrial Fibrillation (AF), Premature Atrial Contraction (PAC)) and hypertension resolved to emergency cardiac surgery on 24-48 hours maximum. Based on a history of SARS-CoV-2 infection, RT-PCR test was performed, and the test result was negative. Otherwise, Chest computed tomography revealed bilateral ground-glass (Figure 1).

After cardiopulmonary bypass

End of the CPB, the patient experienced a drop to saturation. The condition of the airway was investigated for the location of the tracheal tube, the lack of one line trachea, the polarity ventilation of both lungs, and atelectasis. The suction of lung secretions was performed. The ventilator was re-adjusted and the positive end-expiratory pressure (PEEP) 10 was set. Salbutamol was sprayed into the tracheal tube. Despite the expectation of the above treatment approaches, the pulse oximetry device indicates SPO_2=90%. In ABG PO_2: 115 mmHg, O_2sat: 98% was observed (Table 2). Evaluating the amount of urine before and during the CPB (less than 0.5 cc/kg/h), history of CKD represented a reduction in Glomerular Filtration Rate (GFR).

Table 1: Preoperative tests.

128	FBS (mg/dl)
1.5	Cr (mg/dl)
54	BUN (mg/dl)
15	PT (Sec)
49	PTT (Sec)
14.3	Hb (g/dl)
43	HCT (%)
0.78	Troponin (mg/Lliter)
160000	PLT (µL)

FBS: Fasting Blood Sugar, Cr: Creatinine, BUN: Blood Urea Nitrogen, PT: Prothrombin Time, PTT: Partial Thromboplastin Time, Hb: hemoglobin, HCT: hematocrit, PLT: Platelet.

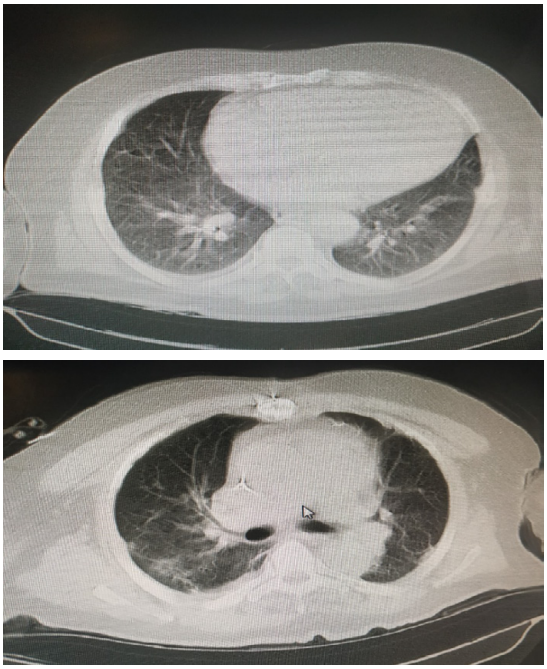

Figure 1: Chest CT before surgery, ground-glass phase.

Table 2: ABG during operation.

	Pre-Bypass	15 Min after Bypass	After cross clamp AO	After Bypass
PH	7.38	7.34	7.38	7.32
PCO2 (mmHg)	40	36	36	34
PO2 (mmHg)	82	513	410	115
O2sat (%)	100	100	100	98
HCO3 (mEg/L)	23	19.4	21.3	17.5
BE	-1.3	-5.8	- 3.4	-7.8
Lactat (mmol/L)	0.9	2	4.7	4.6
HCT (%)	35	27	29	30
Hb (g/dl)	12.6	8.9	9.6	9.9
Glu (mg/dL)	86	115	139	120

PH: Power of Hydrogen, PCO_2: Partial Pressure of Carbon Dioxide, PO_2: Partial Pressure of Oxygen, O_2Sat%: Oxygen Saturated Hemoglobin, HCO_3: Bicarbonate, BE: Base Excess, Glu: Glucose

Intensive care unit (ICU)

Based on initial monitoring and ABG in ICU, evidence of reduction in PO2 and pulmonary dysfunction represented (Table 3). Modifications of ventilator settings were adjusted by anesthesiologist.

On the first day of admission, the total amount of chest tube drainage was 1000 cc in 6 hours. According to the hemodynamic status and the opinion of the surgeon and anesthesiologist, the patient remained intubated until the clinical condition stability for 24 hours.

On the second day, with reduced drainage and improvement of respiratory status extubated. The mask with a reservoir bag was placed on the patient's mouth with an oxygen flow of 10-12 (l/min). but, the patient had some degree of respiratory distress. ABG showed pulmonary dysfunction. Pulmonary consultation, PCR test, and chest Computed Tomography (CT) were performed. The PCR test was negative; however, chest CT illustrated a conversion of the ground-glass phase to the consolidation phase in previously complex

Table 3: ABG 2, 4, 6, 8, 24 hours in ICU.

	First	2h	4h	6h	8h	24h
PH	7.17	7.23	7.26	7.29	7.32	7.49
PCO_2 (mmHg)	57	48	45	45	45	42
PO_2 (mmHg)	57	54	59	67	77	65
O_2sat (%)	68	81	86	91	94	93
HCO_3 (mEg/L)	19.9	20.1	21.6	21.6	23	32.9
BE	-9	-7.5	-6.9	-5	-3	9.7
HCT (%)	35	36	32	34	39	32
Hb (g/dl)	11.6	11.9	10.6	11.2	13.4	11.5
Glu (mg/dL)	146	118	105	111	143	118

pulmonary areas and exacerbation of lesions (Figure 2). Cardiology, anesthesia, and infectious counseling were executed for the patient, and eventually, the infectious disease specialist diagnosed pneumonia. He was confused after extubation and recovered consciousness after 3 days.

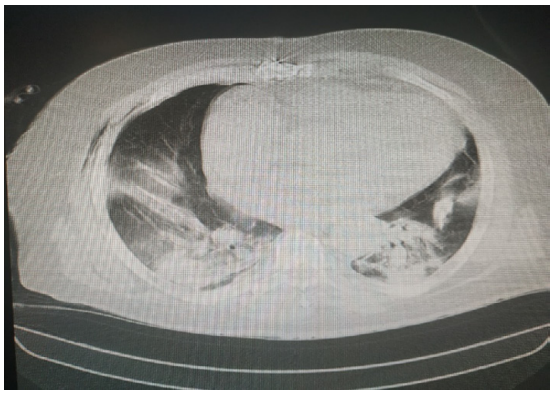

Figure 2: Postoperative chest CT (2 days), the consolidation phase.

On the third day, assessment of fluid intake and urine in the first 24 hours showed signs of oliguria and raise creatinine and BUN. Nephrology consultation was also performed to examine the kidney. Furosemide 5 mg/min infusion was performed.

On the fourth day, platelet count started to decrease and on five days it was below $80*10^9$/L. Urgent hematology consultation was requested and the other reasons for thrombocytopenia investigated. He had hemoptysis and vomiting. Ultimately the patient was transferred to the cardiac care unit after 6 days (Figure 3).

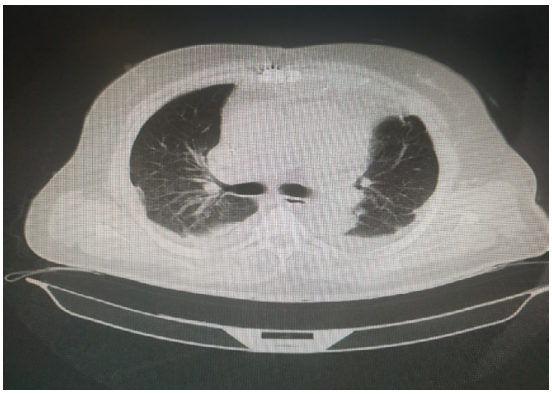

Figure 3: Postoperative chest CT (20 days).

Discussion

The world is experiencing a pandemic of the new SARS-Cov-2 coronavirus called clinical COVID-19. An acute respiratory syndrome is the most significant disorder in all patients with COVID-19 which can have more destructive effects on 17%-29% of COVID-19 patients. 75% of patients had bilateral pneumonia and 14% had bilateral ground-glass facade (2,10-12). This pattern of ground-glass and consolidative pulmonary opacities, often with a bilateral and peripheral lung distribution, is emerging as the chest CT hallmark of COVID-19 infection. Also, X-ray images showed rapid progression of pneumonia and some differences between the left and right lung [13].

Chest CT is a vital component in the diagnostic algorithm for patients with suspected COVID-19 infection. Indeed, given the limited number of rRT-PCR kits in some centers and the possibility of false negative rRT-PCR results, the National Health Commission of Islamic Republic of Iran has encouraged diagnosis based on clinical and chest CT findings alone [14].

Acute respiratory infections may result in activation of coagulation pathways, proinflammatory effects, and endothelial cell dysfunction [15]. COVID-19 patients portend severe levels of cytokine storm and Systemic Inflammatory Response Syndrome (SIRS).

A cytokine profile resembling sHLH is associated with COVID-19 disease severity, characterised by increased interleukin (IL)-2, IL-7, granulocyte-colony stimulating factor, interferon-γ inducible protein 10, monocyte chemoattractant protein 1, macrophage inflammatory protein 1-α, and tumour necrosis factor-α [6] Predictors of fatality from a recent retrospective, multicentre study of 150 confirmed COVID-19 cases in Wuhan, China, included elevated ferritin [6] and IL-6 [2] suggesting that mortality might be due to virally driven hyper inflammation. Endotoxins are the main stimulators of the release of IL-6, IL-8, and granulocyte elastase, which cause respiratory dysfunction and postoperative circulatory instability [16].

however, concern has been expressed that medical therapy for cardiovascular disease might specifically contribute to the severity of illness in patients with COVID-19. This pattern of disease, somewhat similar to that described in earlier coronavirus outbreaks such as SARS and MERS. During the Middle East Respiratory Syndrome (MERS) epidemic, six asymptomatic patients underwent heart surgery, which all the above patients reported a positive coronavirus test result, and five of them died [17].

Huang et al and Wang et al. highlighted an association between lymphopenia and the demand COVID-19 patients to ICU care [6,11]. Several factors may play a role in COVID-19 associated lymphopenia. Lymphocytes express the ACE2 receptor at the cell surface [18]. Afterward, SARS-CoV-2 may directly infect those cells and eventually lead to their lysis. Wu et al. examined risk factors for the development of ARDS and death among 201 patients with SARS-CoV-2-induced pneumonia in Wuhan increase risk of ARDS was significantly associated with raise neutrophils and decreased lymphocytes [19]. Cardiac surgery patients are expected to possess high mortality. These patients cause a major problem. Researchers predict that postoperative risks will increase in these patients.

CPB

Initiation of CPB, ischemia, and reperfusion leads to complement activation, endotoxin release, leukocyte activation, the

release of inflammatory mediators including oxygen free radicals, cytokines (IL6, IL8, TNF), platelet-activating factor, nitric oxide and endothelin [20]. During CPB, endotoxemia at the time of aortic clamp and the peak of release is a short time before the termination [21]. Concentrations of endotoxins after CPB are related to three agents: the amount of vasoconstriction, the duration of the aortic clamp, and the rate of reduction of oncotic pressure due to hemodilution. Factors identified to prevent endotoxin secretion include adequate flow (cardiac index>2.4 l/min/m^2 at normothermia) and perfusion pressure>60 mmHg. There is a potent correlation between mean arterial pressure and endotoxin concentration 10 minutes after the beginning of CPB [22].

On the other hand, cytokines stimulate the inflammatory response by increasing the self-regulation of neutrophil-binding molecules and the accumulation of neutrophils in the lung parenchyma. Neutrophils activated during CPB migrate to inflamed and ischemic organs and then release proteolytic enzymes and cytotoxins, which are responsible for direct lung damage and raised pulmonary permeability, eventually, pulmonary insufficiency occurs after CPB. Elevated IL6 levels after CPB are a predictor of postoperative lung infection [9].

The authors predict, in this case, the synergistic effect of SARS-CoV-2-induced hyper inflammation and SIRS during the pump; It has activated and exacerbated previous lung lesions by SARS-CoV-2 and postoperative pneumonia. On the other hand, blood contact with the circuit components activates a set of enzyme cascades by proteolytic enzymes that activate the complement pathway, fibrinolysis, and internal coagulation, and finally, Complement component 5a (C5a), which has the ability to cause vascular spasm and leukocyte activation. Heparin administration and the presence of pump circuits, pulsating flow, and hemofiltration reduce the production of inflammatory factors [9].

This case report addresses the impact of SARS-CoV-2 patient in undergoing cardiac surgery and postoperative pulmonary complications.

Conclusion

The authors believe; hyper inflammation and cytokine storms in COVID-19 patients in combination with SIRS induce cardiopulmonary bypass lead to severe disorders and exacerbation of previous lesions by SARS-CoV-2. In pandemic conditions, it is reasonable for cardiac surgery patients to be more carefully selected to prevent postoperative mortality and complications. Ambiguities and questions remain, and more research is needed on the effects of SARS-CoV-2on, mortality, complications, pump and temperature effects, and their physiopathology compared to normal COVID-19 patients undergoing cardiac surgery.

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Competing Interests

The authors declare that they have no competing interests.

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Author Affiliations Top

[1]*Department of Anesthesia, School of Paramedical Science, Shahid Beheshti Educational hospital, Qom University of Medical Sciences. Qom, Iran*

[2]*Department of perfusion, Shahid Beheshti Educational hospital, Qom University of Medical Sciences, Qom, Iran*