COVID-19 with Cardiovascular Disease: Can It Help Predict Prognosis?

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ABSTRACT

Two recent articles both found that cardiovascular disease was the major comorbidity in patients with COVID-19. Inflammation of the cardiovascular system and hypoxemia in patients with COVID-19 are the important causes of cardiovascular system dysfunction. Through detailed analyses of the cardiovascular system, clinicians may identify specific patterns of cardiovascular abnormalities. If such a model can been established, the prognosis of COVID-19 patients with cardiovascular disease may be predicted.

In a recent issue of *The Lancet*, Huang et al [2020] reported epidemiological, clinical, laboratory, and radiological characteristics of 41 patients with coronavirus disease 2019 (COVID-19), treatments, and clinical outcomes. Some of the infected patients had cardiovascular disease (CVD) (n = 12; 29.3%). The authors found that CVD was the most common comorbidity of patients with COVID-19 in their research [Huang 2020].

Similarly, in a recent study published in the *British Medical Journal*, Chen et al [2019] analyzed deceased (n = 113) and recovered (n = 161) patients with COVID-19 pneumonia among 799 symptomatic patients. Data collection ended February 28, 2020. The authors found that CVD was more frequent in deceased patients (n = 70; 61.9%) than recovered patients (n = 46; 28.6%). More deceased patients (n = 50; 44.2%) had arterial pressure ≥140 mmHg than recovered patients (n = 33; 20.5%). Median (interquartile range) heart rates of the deceased patients [101.0 bpm (82.0 to 111.0)] were much higher than those of recovered patients [91.0 bpm (79.0 to 104.0)]. More deceased patients tended to have tachycardia (n = 56; 49.6%) than recovered patients (n = 48; 29.8%). Concentrations of hypersensitive cardiac troponin I in the deceased patients [40.8 pg/mL (14.7 to 157.8)] were significantly higher than in recovered patients [3.3 pg/mL (1.9 to 7.0)].

Previous studies have shown a link between CVD and severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) [Chan 2003; Badawi 2016].

Chan et al [2003] found that the presence of comorbidities increased the risk of death in patients with SARS, and CVD was the most important comorbidity in predicting adverse outcomes. A systematic analysis with 637 MERS cases, representing ~40% of the World Health Organization confirmed cases at that time, suggested that hypertension was prevalent in ~25% of the patients, and 30% had cardiac diseases. The study found that the innate and humoral immune systems had been impaired in those patients who had CVD [Badawi 2016].

Hoffmann et al [2020] found that SARS coronavirus 2 (SARS-CoV-2), which caused COVID-19, infected humans via binding of Spike protein on the surface of the virus to the angiotensin-converting enzyme 2 (ACE2) receptor to enter cells and the initiating effect of transmembrane serine protease 2 (TMPRSS2) on Spike protein. They found that blocking access by a TMPRSS2 inhibitor approved for clinical use might constitute a treatment option. ACE2 is mainly expressed in the surface of alveolar epithelial cells and small intestinal epithelial cells and is present in arterial and venous endothelial cells, arterial smooth muscle cells, heart, and kidney [Hamming 2004; Donoghue 2000].

Previous experience with coronavirus and influenza epidemics has shown that viral infection can cause acute coronary syndrome, primarily owing to a significant systemic inflammatory response coupled with localized vascular inflammation at the level of arterial plaque [Madjid 2007]. Huang et al [2020] found that the concentrations of inflammatory factors of COVID-19 patients in the intensive care unit (ICU) were much higher than those in non-ICU patients. SARS-CoV-2 can cause intense release of a variety of cytokines and chemokines, which in turn can cause cardiovascular inflammation and plaque instability. Moreover, once a myocardial infarction has occurred, patients with active COVID-19 are less likely to survive [Huang 2020; Yang 2020].

SARS-CoV-2 can affect the myocardium and cause myocarditis [Xu 2020]. Sporadic autopsy cases have suggested that the myocardium of patients with COVID-19 was infiltrated by interstitial monocytes [Xu 2020]. Cardiac biomarker studies showed a high incidence of cardiac injuries in hospitalized patients with COVID-19 [Xu 2020; Shi 2020]. Shi et al [2020] described 82 patients (19.7%) who had cardiac injuries, 57 of whom died, among 416 hospitalized patients with COVID-19. The mortality rate of patients with heart injury was higher than that of patients without heart injury (42 of 82, 51.2%, versus 15 of 334, 4.5%). Of those deaths, 10.6% had coronary heart disease, 5.3% had cerebrovascular disease, and 4.1% had heart failure.

Hypoxemia may also be an important cause of cardiovascular system dysfunction. Pneumonia due to severe SARS-CoV-2 infection can cause a severe gas exchange barrier, which can lead to hypoxemia. In Chen's study [2019], arterial blood gases were measured in 35 patients with COVID-19 who died and 32 who recovered. The arterial partial pressure of oxygen in the deceased patients [59.2 mmHg (45.4 to 78.6)] was significantly lower than that of recovered patients [121.0 mmHg (90.6 to 163.3)]. Moreover, they found that 77 patients (68.1%) with COVID-19 who died had needed higher levels of oxygen support, compared with only 8 patients (5.0%) who recovered. Hypoxemia can reduce the energy supply of cell metabolism, increase anaerobic fermentation, and produce acidosis. Some studies have found that hypoxemia causes inflammation of the cardiovascular system, damage to cardiomyocytes, development of coronary atherosclerosis, arrhythmia, heart failure, and fibrosis of the cardiovascular system [Abe 2017; Kochi 2020].

These findings will alert clinicians to pay more attention not only to respiratory dysfunction but also to cardiovascular comorbidities and signs of cardiovascular complications in patients with COVID-19. Clinicians can find cardiovascular abnormalities through histories, relevant clinical manifestations, and cardiovascular examinations such as electrocardiography, echocardiography, and coronary angiography. Through detailed analyses of cardiac function grade, hypertension grade, and degree of coronary artery damage, as well as close cardiovascular surveillance, clinicians may identify specific patterns of cardiovascular abnormalities.

If such a model can been established, the prognosis of COVID-19 patients with CVD may be predicted. Judging the prognosis of patients can help clinicians formulate detailed clinical observations and effective treatment methods to improve the cure rate and reduce the mortality rate of patients with COVID-19.

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