



The Impact of the COVID-19 Pandemic and the Importance of Telemedicine in Managing Acute ST Segment Elevation Myocardial Infarction Patients: Preliminary Experience and Literature Review

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Abstract

The coronavirus disease 2019 (COVID-19), which is caused by a novel coronavirus (SARS-COV-2), has compromised health care systems and normal management of patients with cardiovascular diseases [1–3]. Patients with non-communicable diseases, including acute myocardial infarction (AMI) are vulnerable to this stress [4, 5]. Acute ST segment elevation myocardial infarction (STEMI), the most critical type of AMI, is associated with high mortality even with modern medicine [6–8]. Timely reperfusion therapy is critical for STEMI patients because a short ischemia time is associated with better clinical outcomes and lower acute and long-term mortality [9–12]. The COVID-19 pandemic placed the management of STEMI patients in a difficult situation due to the need to balance timely reperfusion therapy and maintaining strict infection control practices [13, 14]. Telemedicine, which is used to deliver health care services using information or communication technology, provides an opportunity to carry out the evaluation, diagnosis, and even monitor the patients after discharge when social distancing is needed [15]. In this article, we reported our preliminary experience with the usefulness of telemedicine in managing STEMI patients during the COVID-19 pandemic. We also provided a review of this topic.

Keywords ST segment elevation myocardial infarction · Telemedicine · COVID-19 · Door-to-balloon time

The COVID-19 pandemic impact on STEMI patient management

The adverse impact of the COVID-19 pandemic on the normal management of STEMI patients includes decreased numbers of STEMI admissions and catheter activation, prolonged systemic delay, altered reperfusion strategies, increased

psychological stress in hospitalized patients, and disruption in cardiac rehabilitation programs.

Decreased numbers of STEMI admissions and catheter activations during the pandemic

The incidence rate of STEMI should be relatively stable in the current society or possibly even higher due to increased psychological stress and lack of exercise due to “lockdown policies” [16, 17]. However, reduced STEMI patients admissions were observed in multiple studies. Zitlney E, et al. reported a 14.6% drop in STEMI admissions in the first three months of 2020 compared with the same period in 2019, even in a region with a relatively low burden of confirmed COVID-19 cases [18]. Zaleski AL, et al. reported a 16 to 38% reduction in STEMI activation per month [19]. De Filippo O, et al. performed a retrospective analysis of clinical and angiographic characteristics of consecutive patients who were admitted for acute coronary syndrome (ACS) at 15 hospitals in northern Italy during the COVID-19 pandemic. They compared the hospitalization rates between the study period and two control

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periods that included a corresponding period during the previous year (February 20 to March 31, 2019) and an earlier period during the same year (January 1 to February 19, 2020) [20]. The mean admission rate for ACS during the study period was 13.3 admissions per day, which was significantly lower than the rate during the earlier period in the same year (18.0 admissions per day) or the rate during the previous year (18.9 admissions per day) [20]. Later, a survey that attempted to assess the impact of the COVID-19 pandemic on STEMI patient admissions demonstrated that 78.8% of the health professionals who responded indicated that the number of patients presenting with STEMI was reduced, and 65.2% of health professionals believed that the reduction in STEMI presentations was greater than 40% [21]. The underlying reasons for the reduction in STEMI admissions included the fear of cross-infection and failure to distinguish cardiac ischemia and COVID-19 related symptoms [22–24].

A reduction in total numbers of STEMI patients who underwent primary percutaneous coronary intervention (PCI) also was observed in several studies. Mayol J et al. reported a 51.2% reduction in PCI for STEMI patients in Latin America during the pandemic [25]. Garcia S, et al. estimated that STEMI patients who underwent primary PCI decreased by approximately 38% in the United States of America during the COVID-19 pandemic [26]. The decrease in primary PCI was associated with a total reduction of STEMI admissions and an increased rate of fibrinolytic treatment or other conservative medical therapies during the pandemic [27]. In a retrospective study conducted by Primessnig U, et al. showed that significantly less patients with AMI were admitted during the pandemic [28].

Prolonged systemic delay in STEMI patients during the pandemic

Multiple investigators have reported increased systemic delay for STEMI patients who underwent primary PCI since the outbreak of the COVID-19 pandemic. Abdelaziz HK, et al. reported a significantly longer symptom-to-first medical contact (FMC) time in STEMI patients during the COVID-19 pandemic (227 [65–790] vs. 119 [27–203] min, $P=0.01$) and 26.1% of STEMI patients experienced late presentation (symptom-to-FMC time that was greater than 12 h) during the COVID-19 pandemic compared with 0% of STEMI patients who experienced late presentation before the pandemic [29]. Gramegna M, et al. reported that 50% of STEMI patients experienced late presentation during the COVID-19 pandemic compared with 4.8% with late presentation before the COVID-19 pandemic [30]. Tam CF, et al. reported significant post-hospital delays in STEMI patients due to the implementation of necessary infection control measures [31]. In a study performed at our center, prolonged pre- and post-hospital delays were observed with STEMI patients during the COVID-

19 pandemic compared with patients before the pandemic [32]. This prolonged systemic delay during the pandemic would ultimately cause adverse clinical outcomes [33].

Altered reperfusion strategies in STEMI patients during the COVID-19 pandemic

Reperfusion therapy, including primary PCI and fibrinolytic therapy, are key therapeutic procedures for STEMI patients [9–11]. The essential goal to achieve better clinical outcomes is to reduce the total ischemia time as much as possible [12, 13]. Current guidelines indicate that primary PCI is the preferred reperfusion therapy because it provides improved clinical benefits with lower rates of re-infarction and bleeding compared with fibrinolytic therapy [9–11]. However, it is still controversial whether primary PCI is the preferred reperfusion therapy during the COVID-19 pandemic when the clinical benefit is largely dependent on rapidly achieving FMC-to-device time within 90 to 120 min [34]. The COVID-19 pandemic has significantly increased the post-hospital delay because isolation catheter labs are not as available, and increased infection control measures are necessary. Experts from China have recommended that fibrinolytic therapy should be considered the first-line therapy during the COVID-19 pandemic [35]. In a retrospective study from our center (paper in submission), fibrinolytic therapy combined with deferred PCI within 24 h resulted in better post-procedure thrombolysis in myocardial infarction (TIMI) flow and similar in-hospital adverse clinical outcomes compared with primary PCI when the screening protocol was used during the pandemic.

Increased adverse psychological stress in hospitalized STEMI patients during the COVID-19 pandemic

The COVID-19 pandemic is a major health crisis resulting in excessive adverse psychological stress in the general population as well as in health care providers. For hospitalized patients, this impact is increasingly evident due to their isolation and when accompanied by any preexisting mental illness [36–38]. This psychological stress can compromise adherence to treatment protocols and subsequently increase the incidence risk of major cardiovascular events [39, 40].

Disrupted cardiac rehabilitation programs

Cardiac rehabilitation (CR) is a valuable treatment and plays an essential role in managing patients experiencing a broad spectrum of cardiovascular diseases [41]. Current guidelines highlight the importance of CR in patients with acute myocardial infarction [9–11]. A typical CR program consists of inpatient rehabilitation and post-discharge rehabilitation, which provide clinical benefits to patients with cardiovascular disease [42, 43]. Both in-hospital and post-discharge CR

programs have been compromised due to the COVID-19 pandemic due to the necessary infection control measures.

The role of telemedicine in managing STEMI patients during the COVID-19 pandemic

As mentioned above, the main reasons for the reduction in STEMI admissions are the fear of infection and limited medical knowledge concerning STEMI. Telemedicine provides an alternative avenue to provide medical education for STEMI patients and avoid unnecessary mortality. Observational studies and meta-analyses have revealed that telemedicine can be used to reduce the pre-hospital delay for patients who underwent primary PCI [32, 44–46]. Telemedicine services also provide additional clinical information, which can help cardiologists carry out diagnoses and differential diagnoses without in-person visits [47, 48]. Remote patient monitoring is another promising aspect of telemedicine, which involves more complex strategies, including smartphone applications (apps), global positioning systems (GPS), and Bluetooth technologies [49–51]. The efficacy of remote telemedicine monitoring in improving clinical outcomes for patients with cardiovascular disease has been discussed previously [52–54]. Because health care services will continue to be compromised during the COVID-19 pandemic, telemedicine provided an effective method to manage patients with cardiovascular disease, including online consultation, video inquiry, internet-based drug prescriptions, pre-hospital diagnoses and patient distribution, post-discharge patient follow up, and CR monitoring.

Preliminary experiences with using telemedicine to manage STEMI patients at our center

The Tiantanzhixin application (app) is a smartphone-based interactive application developed by the department of cardiovascular and macrovascular disease, Beijing Tiantan Hospital, Capital Medical University. It was launched in August 2019, and more than 6000 patients who have visited our out-patient clinic or were hospitalized in our patient ward have been registered in the program (Fig. 1). This free-of-charge application allows real-time, two-way communication between registered patients and doctors from our center. We compared the critical time interval and clinical outcomes for STEMI patients who used the app with those who did not. The patients who used the app exhibited shorter systemic delays compared to those who did not [32]. Although the short-term adverse clinical outcomes were comparable between the two groups, results from the three-month follow-up interactions indicated that the STEMI patients who used the app presented higher left ventricular ejection fractions and lower left ventricular end-diastolic diameters (paper in submission).

This app also allows online communication between patients’ registered relatives and the doctor in charge of the patient, which helps reduce the psychological stress for the patients and their relatives. The use of the app also increased patient satisfaction during hospitalization (paper in submission). Finally, this app could facilitate STEMI patients to remotely perform the CR programs and optimize medical therapies through online and video chats (Fig. 2).

Other designated telemedicine tools besides the Tiantanzhixin app have been shown to be effective in managing patients with different types of cardiovascular disease. Liu



Fig. 1 Cockpit view of the control panel for the Tiantanzhixin app

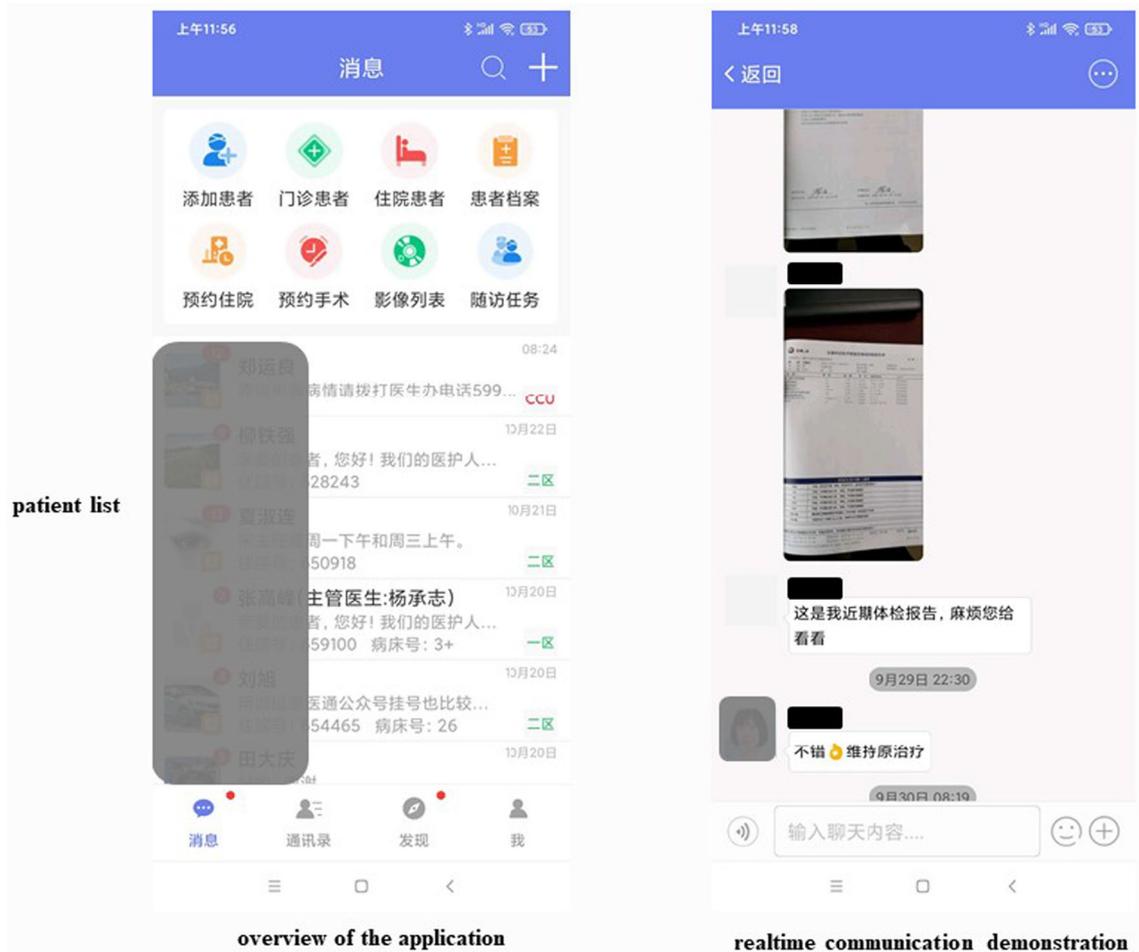


Fig. 2 Screenshots of the Tiantanzhixin app

H et al. reported that pre-hospital electrocardiography (ECG) transfer using the Wechat app (a popular social media application in China) resulted in earlier reperfusion of ST elevation myocardial infarction patients who were transferred from the non-percutaneous coronary intervention center [55]. Hur S et al. observed that the automated Fast Healthcare Interoperability Resources (FHIR)-based 12-lead ECG mobile alert system was successfully implemented in an emergency department, especially for older patients [56]. In a study that enrolled 897 suitable AMI patients, Ben-Assa E, et al. demonstrated that telemedicine technology exhibited considerable promise in reducing 30-day readmission rates for post-AMI patients [57]. The efficacy and safety of telemedicine in managing hypertension have been proven in multiple studies [58–61]. Recently, a meta-analysis revealed that telemedicine positively affected blood pressure control and could be a promising alternative in managing hypertension [62]. The potential role of telemedicine in managing heart failure patients has also been reported in multiple articles. Frederix I, et al. revealed that an initial six-month telemonitoring program was not associated with a reduction in mortalities from all causes in chronic heart failure patients at long-term follow-up [63].

However, they did observe a reduced number of days lost due to heart failure readmissions [63].

The telemedical interventional management in heart failure II (TIM-HF₂) is a randomized, controlled, parallel-group, unmasked trial, which indicated that a structured remote patient management intervention, when used in a well-defined heart failure population, could reduce the percentage of days lost due to unplanned cardiovascular hospital admissions and mortality of all-causes [64]. Guo X et al. demonstrated the efficacy of a hospital-community-family-based telehealth program for patients with chronic heart failure [65]. The efficacy of telemedicine in patients with arrhythmia also was proven in several studies. The mAF App trial was based on a smartphone AF app (mAFA) designed to incorporate clinical decision-support tools. The pilot mAFA trial was the first prospective randomized trial using mobile health technology in patients with atrial fibrillation [66]. The results demonstrated that the mAF app, with integration of clinical decision support, education, and patient involvement strategies, significantly improved patient knowledge, drug adherence, quality of life, and anticoagulation outcomes [66]. The Apple Heart Study is a large-scale, app-based study that has been carried

Table 1 Functional comparison of the Tiantanzhixin app and other telemedicine tools used to manage patients with cardiovascular diseases

Name of the telemedicine	Type of telemedicine	Target population	Medical education	Pre-hospital diagnose and evaluation	ECG transmission	Online consult	Medical professionals online service	Vital signs and test results monitor during hospitalization	Vital signs monitor after discharge	Cardiac follow up after discharge
Tiantanzhixin App	Smartphone application	All	✓	✓	✓	✓	✓	×	×	✓
Social media App (Wechat, Ticktock, Facebook, etc)	Smartphone application	All	✓	✓	✓	×	×	×	×	×
Brunetti et al	Pre-hospital transmission	Acute myocardial infarction patients	×	✓	✓	×	×	×	×	×
Boman, et al	consultation	All	×	✓	×	×	×	×	×	×
Corrie Health Digital Platform (iShare)	Smartphone application	Acute myocardial infarction patients	✓	×	NA	✓	NA	×	✓	✓
iVitality app	Smartphone application, website, BP monitor	Hypertension patients	×	×	×	×	×	NA	✓	×
Medisafe app	Smartphone application	Hypertension patients	✓	×	×	×	×	×	×	×
CONNECT website/app	Website and Smartphone application	All	✓	×	×	×	×	NA	✓	NA
CardioMobile	Smartphone application	Cardiac rehabilitation after PCI or ACS	✓	×	×	×	×	NA	✓	✓
EU-CaRE	Smartphone, HR monitor	Older patients who declined traditional cardiac rehabilitation	✓	×	×	×	×	NA	✓	✓
iCor	Tablet with Bluetooth connection to BP monitor, scale; video conferencing	Symptomatic heart failure patients	✓	×	×	NA	NA	NA	✓	✓
CarePartner	Interactive automated voice response calls, automated e-mails	heart failure patients	NA	×	×	×	×	×	×	×
mAFA	smartphone application	Atrial fibrillation patients	✓	×	×	×	×	NA	✓	×
mSTOPS	Portable ECG (iRhythm Zio) self-applied patch	Atrial fibrillation patients	×	×	×	×	×	NA	✓	×
eMocial	smartphone-based support tool	ACS patients	×	×	NA	NA	×	NA	✓	×

out to identify cardiac arrhythmias using a smartwatch, which will provide the initial evidence that a smartwatch algorithm can identify pulse irregularity and variability, which might reflect previously unknown atrial fibrillation [67]. The detailed functional comparisons for the Tiantanzhixin app and other different types of telemedicine tools are shown in Table 1.

A proposed telemedicine-based protocol to manage STEMI patients during the COVID-19 pandemic

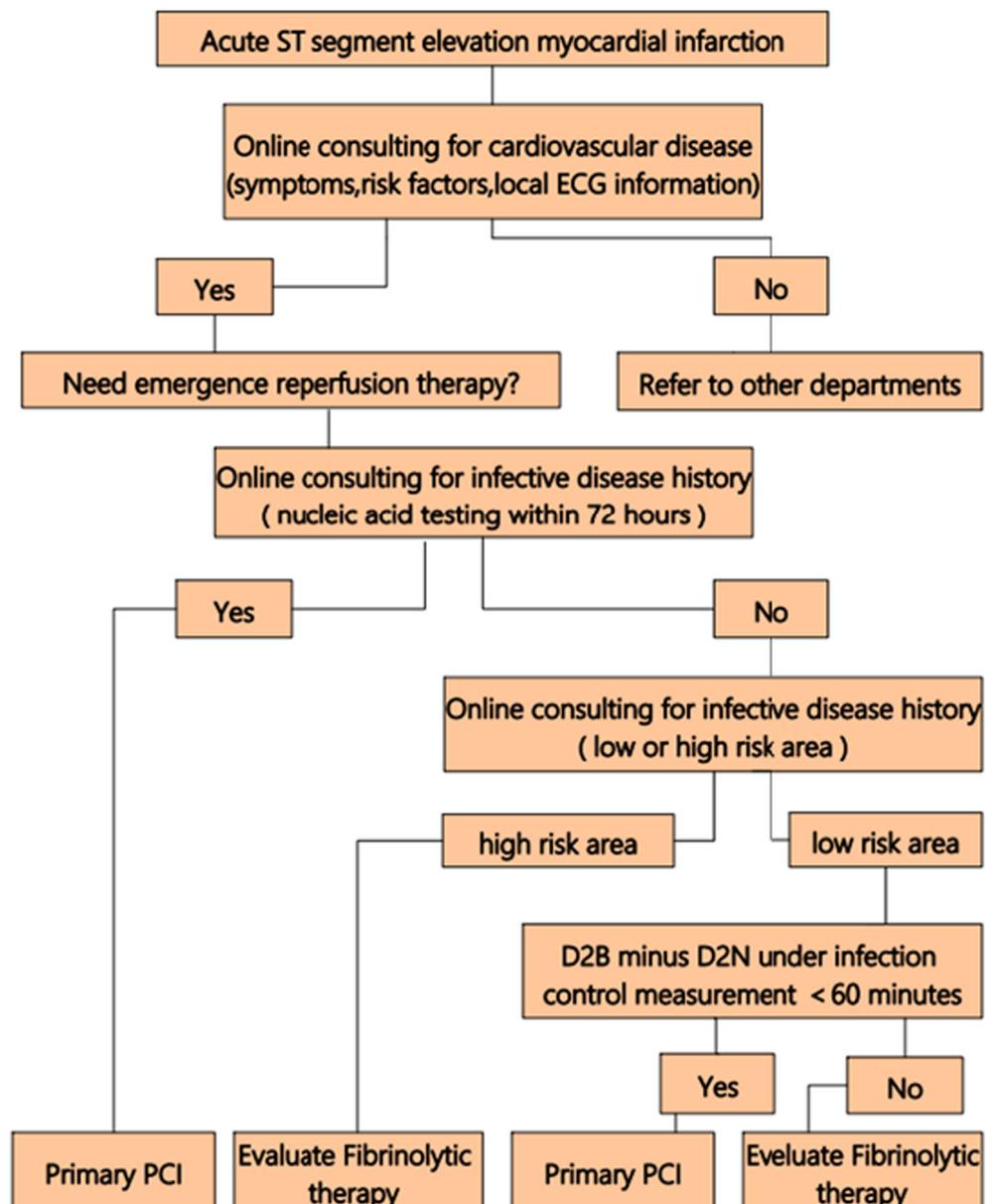
The COVID-19 pandemic has changed the normal medical services and telemedicine, and these techniques offer

alternative strategies to evaluate patients and help doctors make better decisions for their patients, especially when social distancing is necessary. Thus, we have proposed a telemedicine-based protocol to manage STEMI patients during the COVID-19 pandemic, illustrated in Fig. 3.

Future prospects for telemedicine to successfully manage STEMI patients during the COVID-19 pandemic

The COVID-19 pandemic has resulted in reduced numbers of STEMI admissions and catheter activation. The pandemic also has prolonged the systemic delay before and after hospitalization. To resolve these issues, improved essential medical

Fig. 3 Telemedicine-based management protocol used with STEMI patients during the COVID-19 pandemic. D2B:door-to-balloon time, D2N:door-to-needle time



education is needed for high-risk patients, especially patients who have experienced STEMI. With the help of modern technology, telemedicine could provide needed medical services without in-person visits. Wearable medical devices could provide additional patient information, including heart rate, body weight, blood pressure, and others [68–71]. Also, 5G, virtual reality could be used in telemedicine [72, 73].

The need to pool data from multiple sources also is essential. During the COVID-19 pandemic, many academic and commercial entities have been using smartphone apps and online websites to collect data by encouraging patients to submit their symptoms and basic demographic data. These apps are collectively known as Symptom Tracking apps. The OASIS project collects data from third-party app providers to help the NHS respond to the COVID-19 pandemic. By pooling the data from these resources, valuable clinical data can be efficiently collected and analyzed.

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Compliance with ethical standards

Conflict of interest None.

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