Case report

Community and healthcare system-related factors feeding the phenomenon of evading medical attention for time-dependent emergencies during COVID-19 crisis

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SUMMARY
The current COVID-19 crisis has significantly impacted healthcare systems worldwide. There has been a palpable increase in public avoidance of hospitals, which has interfered in timely care of critical cardiovascular conditions. Complications from late presentation of myocardial infarction, which had become a rarity, resurfaced during the pandemic. We present two such encounters that occurred due to delay in seeking medical care following myocardial infarction due to the fear of contracting COVID-19 in the hospital. Moreover, a comprehensive review of literature is performed to illustrate the potential factors delaying and decreasing timely presentations and interventions for time-dependent medical emergencies like ST-segment elevation myocardial infarction (STEMI). We emphasise that clinicians should remain vigilant of encountering rare and catastrophic complications of STEMI during this current era of COVID-19 pandemic.

BACKGROUND
A dramatic and perplexing drop in ST-segment elevation myocardial infarction (STEMI) admissions has been observed during the current COVID-19 crisis. Anecdotal evidence suggests that the principal reason behind this is patient’s anxiety to avoid seeking medical care at hospitals and overwhelmed healthcare systems due to the pandemic. Patients are less inclined to visit hospitals with fear of acquiring COVID-19. Many patients with risk factors of STEMI may dismiss their angina symptoms as benign relative to this fear. This attitude of medical care avoidance has led to delay in hospital presentations, with dire consequences. Furthermore, the COVID-19 pandemic has impacted the healthcare system’s maintenance of operational integrity of high-acuity patients. Herein, we chronicle two cases of delayed presentations of STEMI with rare complications that we encountered at our centre in the month of April 2020. Both patients belonged to the Cuyahoga county of the state of Ohio, USA. They avoided medical care for a time-dependent medical emergency, despite having good social and financial support and easy access to tertiary percutaneous coronary intervention (PCI) capable healthcare facilities. Their dramatic presentation of STEMI with a complicated clinical course and outcomes could have been prevented by an early referral to emergency medical services. This was the time period when the Cuyahoga county was one of the most severely affected regions of Ohio with the most COVID-19 fatalities reported across the state.

CASE PRESENTATION
Case presentation 1
Patient 1 is a 62-year-old Caucasian woman who presented to the emergency department (ED) with shortness of breath and dizziness for 1 day. She stated having nausea and diarrhoea for 2 weeks, associated with intermittent chest pain. She was hesitant getting medical attention and her symptoms got complicated with shortness of breath and dizziness. Her medical history is significant for lifelong cigarette smoking, obesity (BMI of 38 kg/m²) and untreated hyperlipidaemia. On presentation, she had a blood pressure of 96/69 mm Hg, heart rate of 89 beats per minute (bpm), temperature of 98.7°F and respiratory rate of 14 breaths/minute. Physical examination showed an anxious woman with cold extremities, tachycardia with no murmurs and increased effort of breathing with a benign abdominal examination. While in the emergency room, patient became haemodynamically unstable and her rhythm converted to ventricular tachycardia (VT) requiring successful cardioversion on three subsequent occasions following which she was transferred to the intensive care unit (ICU) for VT storm.

Investigations
ECG revealed a wide complex tachycardia at a rate of 200 bpm (figure 1A), high sensitivity troponin T (TnT) was 1151 mg/L (normal <12 mg/L) and proBNP of 34 430 pg/mL (normal <125 pg/mL). COVID-19 testing with nasopharyngeal swab was negative and chest X-ray revealed bilateral opacities. Complete blood count showed leucocytosis, serum lactate 6.6 mmol/L (normal 0.5–2.2 mmol/L), alanine aminotransferase 6497 U/L (normal 7–38 U/L) and aspartate aminotransferase 14739 U/L (normal 13–35 U/L).

Treatment
Synchronised cardioversion with three successive shocks were performed for VT storm, with
conversion to sinus rhythm with repolarisation changes in inferior leads (figure 1B). She was intubated and transferred to ICU on infusion of amiodarone and lidocaine. Over the next hour, she became progressively hypotensive with cold extremities requiring vasopressor support. A transthoracic echocardiogram (TTE) revealed severely reduced biventricular function. Patient was transferred to the cardiac catheterisation laboratory, left and right heart catheterisation (LHC/RHC) performed. RHC revealed the patient to be in cardiogenic shock (table 1).

LHC revealed total occlusion of the mid-distal right coronary artery (RCA) and 90% stenosis of the left anterior descending artery (LAD) (figure 2a and b). During an attempt to cross the RCA lesion with a guidewire, patient became asystolic. Advanced cardiac life support was instituted with return of spontaneous circulation in 3 min. A temporary pacemaker was implanted and three drug eluting stents were placed in the RCA with TIMI 2 flow post-revascularisation. Due to small diameter iliac arteries, an intra-aortic balloon pump was favoured over an Impella device for haemodynamic support for cardiogenic shock. Patient was transferred to the ICU with an augmented systolic blood pressure of 70 mm Hg.

Outcome and follow-up
She became progressively acidotic despite haemodynamic support and her lactate climbed to 9.1 mmol/L, indicating worsening cardiogenic shock. A temporary pacemaker was escalated to venoarterial extracorporeal membrane oxygenation (VA-ECMO). Patient remained on VA-ECMO for 6 days and was successfully decannulated on day 7. Repeat TTE revealed mildly decreased systolic function with a left ventricular ejection fraction (LVEF) of 50%. Patient is currently recovering on the regular medical floor.

Case presentation 2
Patient 2 is an 82-year-old Caucasian woman who presented to the ED with worsening shortness of breath and leg swelling for 2 days. Her history included coronary artery disease (CAD) with remote angioplasty in 1995, peripheral vascular disease, hypertension, hyperlipidaemia, gastro-oesophageal reflux disease and chronic smoking. She reported waking up with chest pressure followed by vomiting 12 days prior to presentation. She was reluctant to visit the ED in ongoing viral pandemic and instead visited her primary care physician’s office. ECG during the office visit was unremarkable, her symptoms were considered atypical and she was sent home on pantoprazole. However, new onset worsening shortness of breath prompted her to report to the ED. On presentation, she had a blood pressure of 116/77 mm Hg, heart rate of 97 bpm, temperature of 97.1°F and respiratory rate of 21 breaths/minute. Physical examination revealed a systolic murmur in the third intercostal space along the left sternal border and crackles in the lung bases.

Investigations
ECG revealed ST-segment elevations in leads V2–V6 with Q waves in leads I, aVL, V5–V6 (figure 3). TnT was elevated to 0.718 ng/mL (normal 0–0.029 ng/mL) and proBNP was 13 346 pg/mL.

Treatment
Patient was administered aspirin 325 mg and clopidogrel 300 mg and started on a heparin infusion. An emergent TTE revealed severely decreased LV function with an EF of 30%, right ventricular systolic pressure of 57 mm Hg and a muscular ventricular septal rupture in the mid anteroseptal wall (figure 4). Patient underwent combined LHC/RHC with saturation study. RHC was significant for a pulmonary capillary wedge pressure of 28 mm Hg and LHC revealed acute total occlusion of the proximal LAD, diffuse 40% stenosis in the LCx, 70% stenosis of ramus
intermedius and 40% stenosis of mid-RCA (figure S5A–C). A left ventriculogram confirmed a muscular ventricular septal rupture (VSR) (figure 5D). There was oxygen step up in the right ventricle and pulmonary artery and the Qp/Qs was 1.56 (table 2).

Conservative management of the CAD was pursued of concerns for reperfusion injury of infarcted myocardium. Patient was discharged home on dual antiplatelet therapy, high-intensity statin, beta-blocker and daily furosemide.

**Outcome and follow-up**

On a follow-up visit, 1 week after discharge, patient reported worsening shortness of breath at rest. The symptoms were deemed secondary to increased shunting across the VSR. Her ECG showed Q waves in the inferior leads with residual ST-segment elevations. A cardiac MRI showed a small defect in the mid-anteroseptum (figure 6). Patient underwent percutaneous closure of VSR and tolerated the procedure well. Currently, the patient is recovering on the medical floor with no symptoms of angina or heart failure.

**GLOBAL HEALTH PROBLEM LIST**

There is a delay and decrease in presentations and timely interventions for medical emergencies like STEMI during the current era of COVID-19 crisis.

| Table 2 | Right heart catheterisation measurements in patient 2 |
|---------|------------------------------------------------------|
| **Haemodynamics** | **| |
| Right atrial pressure (mean) | 7 mm Hg (normal 4 mm Hg) |
| Right ventricular pressure (systolic/diastolic) | 48/7 mm Hg (normal 25/5 mm Hg) |
| Pulmonary artery pressure (systolic/diastolic) | 41/28 mm Hg (normal 25/15 mm Hg) |
| Pulmonary capillary wedge pressure (mean) | 28 mm Hg (normal 12 mm Hg) |
| Cardiac output | 5.6 L/min (normal 4–8 L/min) |
| Cardiac Index | 3.2 L/min/m² (normal 2.5–4 L/min/m²) |
| Systemic vascular resistance | 986 dynes/sec/cm² (normal 800–1200 dynes/sec/cm²) |
| Pulmonary vascular resistance | 129 dynes/sec/cm² (normal 100–200 dynes/sec/cm²) |
| **Oxygen saturations** | **| |
| Inferior vena cava | 73% |
| Superior vena cava | 69% |
| Right atrium | 70% |
| Right ventricle | 72% |
| Pulmonary artery | 79% |
| Systemic | 95% |
| Qp/Qs | 1.56 |

There is a resultant increase in mechanical and arrhythmogenic complications of STEMI as a presenting encounter, a rarity in the age of primary PPCI (PPCI).

Healthcare providers need to be vigilant in identification and management of late presentations of STEMI and its complications.

**GLOBAL HEALTH PROBLEM ANALYSIS**

Acute STEMI is the major cause of mortality globally. It is well established that early diagnosis and immediate reperfusion with
PPCI are the most effective to improve outcomes by lowering risk of post-STEMI complications. However, the COVID-19 outbreak has threatened to overwhelm healthcare systems worldwide, potentially overshadowing other medical emergencies, including STEMI. The data from various countries of Europe show a 25%-40% drop in STEMI presentations and admissions as compared with during the peak of pandemic.

In the USA, a comparable decrease in STEMI presentations is reported in different states irrespective of the state’s burden of COVID-19. Findings from the Cleveland Clinic Foundation, a tertiary care referral centre, also show a consistent reduction in emergency transfers for STEMI and other time-dependent emergencies coinciding with the COVID-19 pandemic.

Garcia et al analysed and quantified STEMI activations for nine high volume cardiac catheterisation laboratories in the USA and found a 38% decrease in STEMI activations of cardiac catheterisation laboratories across the US during the COVID-19 period. A recent international survey was conducted by the European Society of Cardiology (ESC) looking at the perception of cardiology care providers with regards to STEMI admissions to their hospitals. The investigators found a significant reduction in number of STEMI admissions (>40%), an increase in presentations beyond the optimal window for PPCI or thrombolysis (>40%).

The data from Hong Kong reported an increase in time taken for STEMI patients to reach the hospital from 82.5 min to 318 min during the pandemic. As a consequence of this latest trend of STEMI-delayed presentation, the number of mechanical and arrhythmogenic complications of STEMI has seen a rise, which is a rare occurrence in the age of PPCI. It corresponds with our clinical experience with the aforementioned patients who were reluctant to visit ED as they would have in normal circumstances. Both of our patients had good family and social support, healthcare insurance to cover for medical expenses, but still evaded medical care for a time-dependent medical emergency. They belong to the Cuyahoga county, one of the three largest counties of Ohio, which has about 7400 hospital beds at 23 registered hospitals, 7427 physicians and 13 PCI-capable healthcare facilities serving a population of approximately 12 million. The decreased rate of hospital presentations for STEMI has paralleled an increased incidence of patients presenting late after STEMI onset. Physicians around the world are reporting severe complications of STEMI from delayed presentations or lack of reperfusion (table 3).

Based on our review we hypothesise:

1. Patients are not presenting to the hospital for medical emergencies
2. Patients with angina symptoms and with/suspected/without COVID-19 are presenting late to the hospital.

Delays in patients seeking medical care, delay in medical testing for suspected patients and delay due to severe COVID-19 related symptoms are observed during the period of crisis. Physicians are observing worsening left ventricular functions, massive myocardial infarctions, life-threatening arrhythmias and cardiogenic shocks as complications of STEMI, a rarity in the age of PPCI. It has translated into an increased mortality, prolonged admissions to the ICU, a grave concern in these times of scarce resources. The observed phenomenon can be attributed to numerable patient and healthcare-related factors.

Community-related factors
The establishment of COVID-19 hospitals is making many patients reluctant to come to the hospital. Patient 1 had concerns whether the Cleveland Clinic was transformed into a COVID-19 hospital. Such misconceptions and confusions along with alterations in patient behaviours of fear of contracting nosocomial COVID-19 are a potential culprit. Moreover, patient 2 attempted to self-medicate herself with pantoprazole until her symptoms got severe. Reduced family contact and supports during lockdown and the stress associated with stay-at-home orders are potential factors for delayed and decreased presentations for time-dependent medical emergencies.

Low levels of exertion at home might not trigger cardiac symptoms and impaired manifestations of STEMI related to neurotropic and neuroinvasive symptoms of COVID-19 can play a role in those affected with the disease. Misinterpretation of STEMI being relatively benign compared with COVID-19 disease along with the fear of infection spread via hospitalised patients and healthcare workers is a common perception among community dwellers.

Healthcare-system-related factors
The COVID-19 pandemic has put tremendous stress on the healthcare system across the world, even affecting countries with established medical resources. It has disrupted the established care pathways and work flow due to overwhelmed EDs. There is a higher threshold of ED referrals by outpatient care providers, as observed with patient 2. Healthcare personnel safety concerns are undeniable, especially with limited staffing resources from high healthcare worker infection rates. The increasing trend of using fibrinolytic therapies to manage STEMI patients in the ED, in an attempt to mitigate system-based delays, has also been described as a causative for re-emergence of rare complications.

Proposed steps to be implemented to halt this trend
There has been press releases from ESC, American College of Cardiology/American Heart Association, and healthcare experts have voiced concern in major newspapers for public awareness. Many patients, their families and their caregivers have come forward to share their experiences during this period of crisis. On the media page of the Cleveland Clinic,
| Author | Country | Publication month/year | Age/sex | Comorbidities | Clinical presentation | COVID-19 status | ECG/ cardiac enzymes | Multimodality imaging | Invasive findings | Management | Clinical course | Outcome |
|--------|---------|------------------------|---------|---------------|----------------------|-----------------|---------------------|---------------------|------------------|------------|----------------|---------|
| Momoriri et al | Italy | March/2020 | 64/M | Not reported | Left lower limb pain, dyspnea and paroxysms for 10 days, CP and SOB for 10 days | NR | Q waves and STE in inferior leads | TTE: severe LV dilatation, systolic dysfunction and apical thrombosis. CTA: LAD occlusion, thromboembolic material in femoral arteries | Not performed | Emergent amputation of left lower limb | Cardiogenic shock necessitating imotropes and IABP | Recovered and discharged from ICU |
| Moroni et al | Italy | March/2020 | 65/F | Not reported | Progressive SOB for 5 days, hypotension and respiratory distress. Exhausted history of chronic obstructive pulmonary disease with arterial hypertension | NR | Q waves and STE anterior leads | TTE: severe LV dysfunction, apical aneurysm, anteroseptal and anterolateral dyssynchrony. CTA: critical LAD stenosis | Not performed | Inotropic support and non-invasive ventilation | Not significant | Transferred to cardiology ward |
| Gadella et al | Spain | April/2020 | 65/F | Dyslipidaemia, chronic hepatitis C, chronic liver disease with surgical removal and active smoking | Typical CP for 24 hours, low-grade fever and dry cough, and tachypnoea | Acute evolving anterior MI | CXR: bilateral pulmonary infiltrates. TTE: extensive wall motion abnormalities and severe systolic dysfunction | Coronary angiography and PTCA deferred and considered elective after recovery from COVID-19 | Aspirin, clopidogrel, heparin and hydroxychloroquine | Cardiogenic shock in 24 hours. New onset holosystolic murmur and 11 mm arterial Doppler | Not reported |
| Utah et al | USA | May/2020 | 36/M | No comorbidities | Unresponsive at home and last seen normal 15 hours ago | STEV2–V4, TnT-elevated | TTE: extensive septal, anterior and right ventricular wall motion abnormalities. CXR: bilateral patchy infiltrates. | LHC: 99% occlusion of LAD | DES in LAD, aspirin, clopidogrel, heparin and IABP | Discharged from hospital | Not reported |
| Dash et al | India | June/2020 | 59/F | HTN, DM, CAD with PCI in March 2020 | Dyspnoea for 2 days, tachycardia and hypotension | Left atrial dilatation with Q wave in anterior leads, TnT positive | Not performed | Non-invasive ventilation, intravenous inotropes, heparin, anticoagulants, lipid lowering agents and antibiotics | Gradual oliguria followed by ARF with severe metabolic acidosis and refractory hypotension | Cardiac arrest and died | Not reported |
| Dash et al | India | June/2020 | 60/M | DM and HTN | Anginal chest pain, dyspnoea and autonomic symptoms | Qs complex in V1–V4, TnT + | TTE: inferior, inferoseptal, inferolateral and proximal–mid anteroseptal wall hypokinesis. CXR: cardiomediastinal with bilateral alveolar opacities | LHC: 99% stenosis of mid RCA, OCT of LCx and OM1, RHC: Qp:Qs 2.2:1 | Repeated thrombosuction of LAD and DES to RCA. | Discharged from hospital with symptom relief | Not reported |
| Dash et al | India | June/2020 | 64/F | 40-pack year smoking and increased body weight | Chest pain for more than 12 hours | STE in V4 with reciprocal ST depression | Not performed | Revascularisation of LAD and DES to RCA. | Patient wished comfort measures and died after 12 hours | Not reported |
| Mitovska et al | North Macedonia | May/2020 | 47/M | HTN, DM II, smoking and increased body weight | Repeated episodes of CP for 2 days prior to hospitalisation | Sinus tachycardia with STE in leads II, III, aVF, ST > 0.1 mm in II, III, aVF, V1 and V5 and T wave inversion in V5 | TTE: akinesia of apex, anteroseptal wall and inferolateral wall motion abnormalities. LV function with EF 35% | 99% stenosis of mid RCA and 95% stenosis of RCA | DES to culprit lesion in mid RCA followed by another stage procedure with DES to proximal RCA on day 3 of hospitalisation | Anirinol, calcium antagonist, beta-blockers and improved symptoms | Not reported |
| El-Sakr and Marshall | USA | June/2020 | 64/F | 40-pack year smoking and increased body weight | 40-pack year smoking and increased body weight | Chest pain for 4 days, dyspnoea and fever. Systolic thrill on examination | STE in II, III, aVF, V3–V6 with reciprocal changes in I and aVL | LHC: occluded mid RCA, LVEDP 33 mm Hg (normal <15 mm Hg) and RHC: 75% stenosis on RV cavo pulmonary shunt and PCWP of 26 mm Hg (normal <12 mm Hg) | IABP support, nutritional support and DES to RCA. | Postoperative bleeding requiring reoperation | Died |
| Joshi et al | USA | June/2020 | 72/F | Dyslipidaemia and CAD with PCI in 2002 | Subcostal chest heaviness, light tenderness and persistent paroxysms 14 hours after persistent symptoms | STE in inferior leads with Q waves, reciprocal ST depression and elevated TnT | CTA: insignificant | LHC: occlusion of mid RCA and ventriculogram showed VSR. RHC: Q wave in I, RV and LHV 90% | DES to mid RCA | Patient wished comfort measures and died | Not reported |
| Abidawi et al | USA | June/2020 | 63/M | CAD with prior PCI | Delays in seeking medical advice and presentation after 14 hours | Inferior STE with Q waves and elevated TnT | TTE: EF 50% and hypokinesia of inferior and inferoseptal mycardium | LHC: dominant RCA totally occluded and tricuspid atresia with atrial septal defect with tricuspid atresia with atrial septal defect | Atrial fibrillation with symptom resolution | Discharged and presented with shock and new murmur 5 days later and found to have VSR | Complex VSD repair and IABP admission | Died |
| Abidawi et al | USA | June/2020 | 63/M | HTN and MS | Chest pain for 4 days, dyspnoea and fever. Systolic thrill on examination | Anterior STE with Q waves | TTE: EF 35% with LAD/OM1, apical VSR | LHC: severe LV dysfunciton and Q wave in V2–V6. RHC: Q wave in I, RV and LHV 90% | Patient elected non-invasive management | Transcripted to hospice care | Not reported |
| COVID-19 status | ECG/cardiac enzymes | Multimodality imaging | Invasive findings | Management | Clinical course | Outcome |
|----------------|--------------------|----------------------|------------------|------------|----------------|--------|
| Posterior STE  | TTE: EF 25% and small LHC: 100% occlusion of LAD. Unable to wear or discharge on day 19 | Associated with arrhythmogenic complications of non-revascularised STEMI, rarely encountered in the age of primary percutaneous coronary intervention. | Asystole during PCI and successful decannulation. Recovering on medical floor. | Antiplatelets, statin and anticoagulation. | Initially received tenecteplase, transferred to ICU on IABP. | Recovering well on medical floor. |
| TTE: EF 25% and small LHC: 100% occlusion of LAD. Unable to wear or discharge on day 19 | Antiplatelets, statin and anticoagulation. | Associated with arrhythmogenic complications of non-revascularised STEMI, rarely encountered in the age of primary percutaneous coronary intervention. | Asystole during PCI and successful decannulation. Recovering on medical floor. | Initially received tenecteplase, transferred to ICU on IABP. | Recovering well on medical floor. |
| Coronary artery disease, HTN, hyperlipidaemia and obesity | Left ventricular assist device (LVAD) | Anticoagulation and mechanical complications, with a prolonged and arduous clinical course. | Ongoing anticoagulation and mechanical complications, with a prolonged and arduous clinical course. | Anticoagulation and mechanical complications, with a prolonged and arduous clinical course. | Anticoagulation and mechanical complications, with a prolonged and arduous clinical course. |
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**Learning points**

- Several community and healthcare-system-related factors delay and decrease the presentation and intervention for time-dependent non-communicable diseases such as ST-segment elevation myocardial infarction (STEMI) in the era of COVID-19 crisis.
- As a consequence of these delays, healthcare providers should be vigilant in encountering and managing devastating complications of non-revascularised STEMI, rarely encountered in the age of primary percutaneous coronary intervention.
- We present two intriguing cases of delayed presentation of STEMI in the era of COVID-19 pandemic with arrhythmogenic and mechanical complications, with a prolonged and arduous clinical course.
- This review focuses on several important patient and healthcare-system-related factors playing a vital role in this perplexing observation.
- Several vital steps are postulated to halt this dangerous trend and assure the safety and well-being of general population in case a second wave of the pandemic develops.

Cardiovascular experts have explained in simple terms the tell-tale signs of a heart attack as well as how delaying heart care in this COVID-19 surge can lead to devastating consequences. As the pandemic continues, it is imperative to commit stern steps of mass education and public awareness. Identification and correction of internal process delays is vital. The utilisation of telemedicine strategies, according to recent reports, was associated with improvement of STEMI time of diagnosis and outcomes during the period of crisis. Further studies comparing telemedicine to the conventional way of managing patients with ACS are need of the hour.

Altogether, these findings should be taken into serious consideration and effective plans drawn and implemented in case a second wave of the pandemic develops as lockdown restrictions are currently eased worldwide.

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