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# Long-Term COVID: Post Acute COVID-19 Cardiac Care

Jeffrey J. Hsu, MD, PhD  
 Clinical Instructor, Division of Cardiology  
 Associate Director, UCLA COVID Cardiology Program  
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## Disclosures

- No relevant financial disclosures

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## Introduction

### Post Acute COVID-19 Syndrome (PACS)

Persistent symptoms and/or delayed or long-term complications of COVID-19 >4 weeks after symptom onset

Naibedian et al, Nat Med 2021

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## Objectives

- Understand the cardiovascular manifestations of Acute COVID-19 disease and Post-Acute COVID-19 Syndrome (PACS)
- Identify patients who may have cardiovascular sequelae in PACS
- Learn management strategies for these patients

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## SARS-CoV-2 Cell Entry

ACE2: angiotensin converting enzyme-2  
 TMPRSS2: transmembrane protease

Gupta et al, Nat Med 2020

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## COVID-19: Cardiovascular Manifestations

- Myocardial injury & myocarditis
- Acute coronary syndrome
- Heart failure
- Arrhythmias & sudden cardiac arrest
- Coagulation abnormalities & thrombosis

UCLA Health Guzik et al. Cardiovasc Res 2020

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## Myocardial Injury: Damage to the Heart Muscle

Defined as elevations in blood biomarkers (troponin, BNP)

Common in hospitalized COVID-19 patients

Average ~20%

UCLA Health Sandoval et al. JACC 2020

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## Myocardial injury increases risk of death in hospital

UCLA Health Lala et al. JACC. 2020.

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## Myocarditis: Inflammation of Heart Muscle

100 patients recovered from COVID-19:

- 78% with abnormal CMR
- 60% with ongoing inflammation
- Not associated with severity of symptoms

Cardiac MRI (CMR)

UCLA Health Puntmann et al. JAMA Cardiology 2020

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## Myocarditis: Less Common than Initially Feared

145 college athletes recovered from COVID-19:

- Only 2 (1.4%) with myocarditis on CMR

Cardiac MRI (CMR)

UCLA Health Starekova et al. JAMA Cardiology 2021

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## SARS-CoV-2 in Myocardial Tissue

But larger pathology studies in autopsies suggest COVID-19 myocarditis is rare

UCLA Health Tavazzi et al. Eur J Heart Failure 2020

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### Acute Coronary Syndrome / Myocardial Infarction

	PE	DVT	Stroke	MI	Other thromboembolism*	Any thrombotic event*	No thrombotic event
All hospitalized patients (ICU and non-ICU) (n = 3334)							
Events, No (%)	106 (3.2)	129 (3.9)	54 (1.6)	298 (8.9)	32 (1.0)	533 (16.0)	2801 (84.0)
All-cause mortality, No. (%)†	40 (37.7)	36 (27.9)	20 (37)	153 (51.3)	11 (34.4)	230 (43.2)	587 (21.0)

Bilaloglu et al., JAMA 2020

**Risk of myocardial infarction (MI) ~5x higher in first 14-days of COVID-19 infection**

Modin et al., Circulation 2020

JAMA Cardiology | Brief Report  
**Assessment of Neutrophil Extracellular Traps in Coronary Thrombus of a Case Series of Patients With COVID-19 and Myocardial Infarction**

Ara Blasco, MD, PhD, María José Coronado, PhD, Fernando Hernández Terésado, MD, Patricia Martín, MD, PhD, Ara Hoyuela, PhD, Eloy Barrio, PhD, Diego García, M.T., Javier González, MD, María Del Tigo, MD, PhD, Javier Ordoña, MD, Juan M. Escalante, MD, PhD, Lorenzo Sola, MD, Carmen Balles, MD, PhD

Blasco et al., JAMA Cardiology 2020

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### Heart Failure in COVID-19

- Echocardiograms of 100 consecutive patients admitted with COVID-19 (Israel):
  - 68% abnormal
  - Right ventricular dilation/dysfunction: 39%
  - Left ventricular systolic dysfunction: 10%
- 118 consecutive patients (NYC)
  - 4.5% with stress-induced cardiomyopathy (Takotsubo / "broken heart syndrome")

Szekely et al., Circulation 2020  
 Guisaino et al., JACC 2020

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### Arrhythmias & Sudden Cardiac Arrest in COVID-19

Atrial fibrillation appears to be most common arrhythmia in hospitalized COVID-19 patients

**WHAT TACHYARRHYTHMIAS HAVE YOU OBSERVED IN COVID-19 POSITIVE PATIENTS?**

AFib (n=48), Atrial flutter (n=10), SVT (n=10), VT (n=10), VF (n=10), SCA (n=10)

**WHAT BRADYARRHYTHMIAS HAVE YOU OBSERVED IN COVID-19 POSITIVE PATIENTS?**

SA node dysfunction (n=10), AV block (n=10), Sinus bradycardia (n=10), Heart block (n=10), SCA (n=10)

Bhatia et al., Heart Rhythm 2020  
 Copinathannair et al., J Interv Card Electrophysiol 2020

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### Arrhythmias & Sudden Cardiac Arrest in COVID-19

- AFib & New AFib incidence similar in both hospitalized COVID-19 & influenza

**Risk Factors for New AFib in COVID-19:** Inflammatory Markers, Myocardial Injury, Ischemia and Myocardium Ischemia, Use of steroids

**Mortality Associated with AFib:** COVID-19 (RR 1.77), Influenza (RR 1.78)

Incidence of AFib identified per automated abstraction in COVID-19<sub>total</sub> and manual chart review in COVID-19<sub>total</sub> in contrast to that seen in patients admitted with influenza. Associated risk factors for new AFib in COVID-19<sub>total</sub>. Relative and absolute risk of mortality associated with in-hospital AFib of patients hospitalized with COVID-19 and influenza.

Muskatlow et al., JACC EP 2021

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### Blood Clotting Abnormalities in COVID-19

	PE	DVT	Stroke	MI	Other thromboembolism*	Any thrombotic event*	No thrombotic event
All hospitalized patients (ICU and non-ICU) (n = 3334)							
Events, No (%)	106 (3.2)	129 (3.9)	54 (1.6)	298 (8.9)	32 (1.0)	533 (16.0)	2801 (84.0)
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Bilaloglu et al., JAMA 2020

PE: Pulmonary Embolism (Clots in Lungs)  
 DVT: Deep Vein Thrombosis (Clots in Large Veins)

**Autopsy study of COVID-19 Patients:**

- 4 out of 12 had PE
- 7 out of 12 had DVT

Wehmann et al., Ann Int Med 2020

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### Clinical Practice Guidance for UCLA Inpatient Cardiology Consult Team

**Flowchart Summary:**

- Thrush with right or clinical signs of cardiac syndrome?
  - Yes: Consider treatment (Clotting, Anti-thrombotic, Anti-thrombotic, Anti-thrombotic) → Limited TTE
  - No: Consider Cardiac POCUS or Limited TTE
- Wait until abnormalities on clinical suspicion concerning for ACS?
  - Yes: Treat for ACS
  - No: Ensure Cardiology Team consulted
- Regional wall motion abnormalities and/or clinical syndrome concerning for ACS?
  - Yes: Regional wall motion abnormalities and/or clinical syndrome concerning for ACS → Consider treatment (Clotting, Anti-thrombotic, Anti-thrombotic, Anti-thrombotic) → Ensure Cardiology Team consulted
  - No: LVEF > 50% → Consider treatment (Clotting, Anti-thrombotic, Anti-thrombotic, Anti-thrombotic) → Ensure Cardiology Team consulted
- Continue to monitor, Reassess prognostic, Consider PE as etiology of response elevation, Consider PE as etiology of response elevation, Consider PE as etiology of response elevation, Consider PE as etiology of response elevation

Adapted from Hendren et al., Circulation 2020

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## Cardiovascular Effects of COVID-19: Long-Term?

The Atlantic

### COVID-19 Can Last for Several Months

The disease's "long-haulers" have endured relentless waves of debilitating symptoms—and disbelief from doctors and friends.

Story by Ed Yong | JUNE 4, 2020 | HEALTH

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## PACS: Symptoms Persist Post-Discharge

Symptom	Acute COVID-19 phase (%)	Post-COVID-19 follow-up (%)
Chest pain	~87	~20
Cough	~40	~10
Shortness of breath	~30	~10
Fatigue	~25	~10
Joint pain	~20	~10
Headache	~15	~10
Sore throat	~10	~10
Diarrhea	~10	~10
Myalgia	~10	~10
Sputum production	~10	~10
Loss of appetite	~10	~10
Loss of taste	~10	~10
Red eyes	~10	~10
Blurred vision	~10	~10
Anosmia	~10	~10

2 months after Hospital Discharge:

- **87% of patients** still with at least one COVID-related symptoms
- ~20% with Chest Pain

Carfi et al. JAMA 2020

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## PACS: Potential Cardiovascular Manifestations

Panel: Conditions experienced by members of the UK doctors #longcovid group

- Myocarditis or pericarditis
- Microvascular angina
- Cardiac arrhythmias, including atrial flutter and atrial fibrillation
- Dysautonomia, including postural orthostatic tachycardia syndrome
- Mast cell activation syndrome
- Interstitial lung disease
- Thromboembolic disease (pulmonary emboli or cerebral venous thrombosis)
- Myelopathy, neuropathy, and neurocognitive disorders
- Renal impairment
- New-onset diabetes and thyroiditis
- Hepatitis and abnormal liver enzymes
- New-onset allergies and anaphylaxis
- Dysphonia

Pericarditis

Myocardial Ischemia

Arrhythmias

Postural Orthostatic Tachycardia Syndrome (POTS)

Gerna et al. Lancet, Dec 2020

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## COVID-19: Cardiovascular Presentations

### Unmasking a Condition?

- Coronary artery disease / Ischemia
- Atrial fibrillation

### Causing a Condition?

- Myocarditis / Heart Failure
- Pericarditis
- POTS

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## Post Acute COVID-19 Cardiovascular Care

### Objectives

- Rule out high-risk cardiovascular conditions
  - Myocarditis
  - Severe coronary ischemia
  - Ventricular arrhythmias
- Diagnose and manage symptomatic conditions
  - Pericarditis
  - Dysautonomia / POTS
  - Arrhythmias (i.e., atrial fibrillation)

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## CASE #1:

48 yo F with COVID-19+ in May 2020

- Intermittent chest pain x weeks
- TTE in June 2020: Normal
- Chest pain improved over summer, but returned in winter. +Palpitations, +Dyspnea.
- ECG normal
- Cardiac MRI in Jan 2021:
  - Abnormal delayed enhancement in mid-myocardial segment of inferior LV

Cardiac MRI

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### Rule Out High-Risk Condition: Myocarditis

- **Clinical Features:**
  - Heart Failure symptoms (shortness of breath), chest pain, palpitations
- **Laboratory Findings:**
  - ↑ Troponin/CK-MB and/or BNP, possibly ↑ CRP & ESR
- **Imaging Findings:**
  - ECG: ST-T segment abnormalities
  - Echo: thickened myocardium, decreased LVEF, regional abnormalities
  - Cardiac MRI: myocardial edema, non-ischemic injury (i.e., LGE)

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### Rule Out High-Risk Condition: Myocarditis

- **Diagnosis:**
  - Clinical syndrome of myocarditis (e.g., chest pain, dyspnea) **PLUS** objective evidence of myocardial injury (e.g., biomarkers, imaging)
- **Management**
  - Exercise Restriction for 3-6 months
  - Reassess for resolution of inflammatory markers & imaging abnormalities
  - Guideline-directed medical therapy for heart failure if LVEF is reduced

Maron et al. Circulation 2015.  
Kim et al. JAMA Cardiology 2021.

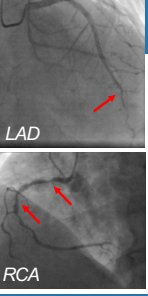
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### CASE #2:

**65 yo M with COVID-19+ in July 2020**

- **PMH:** ESRD on HD (Kidney Tx listed), HTN, DM
- Hospitalized in ICU, no intubation
- Troponin I peak 1.1 ng/ml
- ECG no ischemic changes; TTE normal
- Nuclear Stress Test (Oct 2020): Abnormal
- Coronary Angiogram (Nov 2020):
  - Severe distal LAD & moderate RCA & LCx disease



*Coronary Angiograms*

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### Rule Out High-Risk Condition: Severe Ischemia

- **Clinical Features:**
  - Chest pain, palpitations
- **Laboratory Findings:**
  - ↑ Troponin, CK-MB
- **Imaging Findings:**
  - ECG: ST-T segment abnormalities
  - Echo: regional wall motion abnormalities, decreased LVEF
  - Stress Testing: suggests stress-induced ischemia

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### Rule Out High-Risk Condition: Severe Ischemia

- **Management:**
  - Aspirin, high-intensity statin
  - Consideration of revascularization
  - Aggressive risk factor modification
  - Cardiac rehabilitation

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### Rule Out High-Risk Condition: Ventricular Arrhythmias

- **Clinical Features:**
  - Chest pain, palpitations, dyspnea, syncope
- **Laboratory Findings:**
  - Non-specific
- **Imaging Findings:**
  - ECG: frequent PVCs or non-sustained VT
  - Echo: regional wall motion abnormalities, decreased LVEF
  - Ambulatory ECG monitoring: frequent PVCs or non-sustained VT

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### Diagnose/Manage Conditions: Pericarditis

- **Clinical Features:**
  - Sharp positional chest pain, dyspnea. +Friction rub on exam.
- **Laboratory Findings:**
  - ↑ CRP/ESR, ↑ Troponin/CK-MB (if myopericarditis)
- **Imaging Findings:**
  - ECG: diffuse ST-T segment elevations with PR depression
  - Echo: thickened pericardium +/- pericardial effusion
  - CT/MRI: thickened pericardium +/- pericardial effusion

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### Diagnose/Manage Conditions: Pericarditis

- **Management:**
  - Medications: NSAIDs, Colchicine, Corticosteroids (if refractory to above measures)
  - Exercise Restriction

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### Diagnose/Manage Conditions: POTS

- **Clinical Features:**
  - Palpitations, lightheadedness
  - Inappropriate sinus tachycardia, sustained HR increase >30 beats/min within 10 minutes of standing
- **Laboratory Findings:**
  - Non-specific, but evaluate for other causes of orthostatic hypotension including anemia, electrolyte disorders, thyroid disease, adrenal hormone abnormalities, elevated catecholamines

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### Diagnose/Manage Conditions: POTS

- **Management:**
  - Aggressive hydration, including sodium intake
  - Counterpressure maneuvers
  - Compression garments
  - Isometric exercises
  - Breathwork
  - Avoidance of exacerbating factors
  - Consideration of medication (? Ivabradine)



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### Diagnose/Manage Conditions: Arrhythmias

- **Clinical Features:**
  - Palpitations, lightheadedness
- **Laboratory Findings:**
  - Non-specific, but evaluate for other contributing factors including anemia, electrolyte disorders, thyroid disease, adrenal hormone abnormalities, elevated catecholamines
- **Diagnostic Studies:**
  - ECG, Ambulatory ECG, Exercise stress test

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### Diagnose/Manage Conditions: Arrhythmias

- **Management:**
  - Consideration of rhythm and/or rate control strategies
  - Consideration of anticoagulation

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