

Annals of Clinical Biochemistry

On the Clinical Utility of Cardiac Troponin measurement in COVID-19 Infection

Journal:	<i>Annals of Clinical Biochemistry</i>
Manuscript ID	ACB-20-083.R1
Manuscript Type:	Mini Review
Date Submitted by the Author:	25-Mar-2020
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Keywords:	Troponin < Analytes

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Manuscripts

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3 **Mini Review**
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7 **On the Clinical Utility of Cardiac Troponin measurement in COVID-19 Infection**
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32 **DECLARATIONS**
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34 Conflict of interest: None

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36 Funding: This research received no specific grant from any funding agency in the public,
37 commercial, or not-for-profit sectors.

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39 Ethical approval: Not applicable

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41 Guarantor: DCG

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43 Contributorship: DCG sole author
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49 **Abstract**
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53 The novel coronavirus SARS-CoV-2 causes the disease COVID-19, a severe acute
54 respiratory syndrome. COVID-19 is now a global pandemic and public health emergency
55 due to rapid human-to-human transmission. The impact is far-reaching, with enforced social
56 distancing and isolation, detrimental effects on individual physical activity and mental
57 wellbeing, education in the young and economic impact to business. Whilst most COVID-19
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3 patients demonstrate mild-to-moderate symptoms, those with severe disease progression
4 are at a higher risk of mortality. As more is learnt about this novel disease, it is becoming
5 evident that comorbid cardiovascular disease is associated with a greater severity and
6 increased mortality. Many patients positive for COVID-19 demonstrate increased
7 concentrations of cardiac troponin, creating confusion in clinical interpretation. Whilst
8 myocardial infarction is associated with acute infectious respiratory disease, the majority of
9 COVID-19 patients demonstrate stable cTn rather than the dynamically changing values
10 indicative of an acute coronary syndrome. Although full understanding of the mechanism of
11 cTn release in COVID-19 is currently lacking, this mini-review assesses the limited published
12 literature with a view to offering insight to pathophysiological mechanisms and reported
13 treatment regimens.
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Introduction

The 7th coronavirus known to infect humans is currently proliferating in humans at an alarming rate. The latest virus named SARS-CoV-2 (previously 2019-nCov) causes the disease COVID-19, a severe acute respiratory syndrome (SARS). Following the initial outbreak in Wuhan, China in late 2019, the World Health Organisation (WHO) now considers SARS-CoV-2 a pandemic human viral infection.

At the time of writing (25/3/2020, 12:30) the live situation dashboard of the WHO (<https://experience.arcgis.com/experience/685d0ace521648f8a5beeeee1b9125cd>) reports 375,498 global cases and 16,362 deaths in 195 countries, areas or territories. There are 6,654 confirmed cases and 335 deaths in the United Kingdom.

There has been speculation that the virus was a result of genetic manipulation; however SARS-CoV-2 more likely originated by natural selection in an animal source. The current SARS-CoV-2 virus demonstrates similar genetics to bat SARS-CoV like coronaviruses¹. There is however, no evidence of direct bat-to-human transmission, suggesting an intermediate animal host is involved. This follows similar zoonotic infection routes of other coronaviruses entering into the human population.

There has been a rapid response from the *in vitro* diagnostic industry to develop assays for SARS-CoV-2. These have migrated into UK laboratories at a much faster rate (50,442 tests on 18/3/20) than in the US, due in part to stringent Food and Drug Administration regulations (figure 1). Real-time reverse transcription polymerase chain reaction (RT-PCR) is used for SARS-CoV-2 RNA viral detection in upper and lower respiratory specimens, and serological analysis of anti-COVID-19 antibodies by automated immunoassays can be used for disease surveillance. The preferred testing is by molecular diagnosis of COVID-19 by real-time RT-PCR, such as the RdRp gene assay, which amplifies a conserved region of the RNA-dependent RNA polymerase gene that is specific to SARS-CoV-2, which has been used for confirmation of this disease by Public Health England laboratories. In addition, oligonucleotide primers and probes selected from regions of the virus nucleocapsid (N) gene are also included in the panel. In confirmed COVID-19 cases, the laboratory testing should be repeated to demonstrate viral clearance prior to healthcare discharge.

Incubation, Transmission and Clinical Presentation

The incubation period has been suggested to be approximately 5 days². Transmission is dependent on variable individual infectiousness, population density and spatial distance. The virus is transmitted primarily in respiratory aerosols and by indirect contact with

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3 contaminated surfaces. Faecal analysis detecting viral RNA also suggest a faecal-oral route
4 of transmission³.
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7 The clinical presentation and severity of symptoms is case-dependent. The clinical
8 characteristics in the Chinese population have been recently documented from 1,099
9 cases⁴. The virus has infected more males than females and severity is associated with
10 older age. The common symptoms are fever and a persistent non-productive cough,
11 although many present without fever and often with mild symptoms. The vast majority
12 (>85%) do not demonstrate chest radiographic abnormalities; but ground-glass opacity and
13 bilateral shadowing has been demonstrated on computer tomography in severe cases.
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22 **Laboratory Findings**

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25 Evidence from the Chinese cohort suggests prominent lymphocytopenia occurs in 83% of
26 cases, with thrombocytopenia in 36% and leukopenia in 34%. Biochemically, patients
27 demonstrate high concentrations of C-reactive protein (CRP) and less common elevations in
28 liver enzymes (aspartate aminotransferase and alanine aminotransferase), creatine kinase
29 (CK) and D-dimer⁴. Furthermore, in a systematic analysis of eleven articles, Lippi and
30 Plebani have documented laboratory abnormalities reported in cases of COVID-19⁵. Patients
31 may also present with decreased albumin, or increases in lactate dehydrogenase, total
32 bilirubin, creatinine, procalcitonin and also cardiac troponin and natriuretic peptides.
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42 **Cardiac Troponin elevations in COVID-19**

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44 Previous influenza infection epidemics have been associated with myocardial infarction,
45 myocarditis and exacerbated heart failure⁶. These comorbid conditions contribute to
46 significant mortality. Previous coronavirus epidemics such as SARS in 2002 and Middle
47 East Respiratory Syndrome (MERS) were associated with tachycardia, bradycardia,
48 cardiomegaly, cardiac arrest, sub-clinical diastolic impairment and acute-onset heart failure<sup>7-
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COVID-19 is characterised by pneumonia and persons with underlying cardiovascular
disease associated with hypertension, diabetes, coronary artery disease or cerebral vascular
disease are at higher risk of developing the severest form of the disease and demonstrate
the highest rate of mortality (figure 2). Cardiac complications include the development of

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3 incident heart failure, acute coronary syndrome (ACS) and arrhythmia all of which are
4 associated with elevation in cTn¹² especially when using high sensitivity immunoassays and
5 confer poor prognosis. Elevations in cTn are common in those with acute infectious
6 respiratory disease and increases correlate with the severity of infection¹³.
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10 Evidence of COVID-19-associated increases in circulating cardiac troponin T (cTnT) and
11 cardiac troponin I (cTnI) above the 99th percentile reference limit are emerging in the
12 literature¹⁴⁻¹⁷. Detectable cTnI has been observed in most COVID-19 patients. In a
13 retrospective cohort analysis cTnI was significantly elevated in 54 subjects who died
14 compared to 137 survivors (median [IQR] cTnI 22 [5.6–83.1] ng/L vs 3 [1.1-5.5] ng/L,
15 p=<0.0001)¹⁸.
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21 The mechanism of cTn elevation in COVID-19 infection is not fully understood. Elevations
22 are likely to reflect non-coronary disease rather than acute coronary disease such as
23 myocardial infarction¹⁹. The underlying pathophysiology is suggestive of a cardio-
24 inflammatory response as many critically ill COVID-19 patients demonstrate concomitant
25 elevations in acute phase reactants such as CRP and the natriuretic peptides. This may
26 present clinically as fulminant myocarditis.
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32 In one case report,²⁰ a thirty seven year old male presented with a three-day history of chest
33 pain and dyspnoea. Electrocardiographic changes suggested an ST-segment elevation
34 acute myocardial infarction and cTnT was substantially elevated at >10,000 ng/L (99th
35 percentile reference limit <14 ng/L), with concomitant elevations in CK and b-type natriuretic
36 peptide. The initial working diagnosis was ACS. Subsequent CT coronary angiography
37 revealed no evidence of coronary stenosis. A sputum sample was assayed for 13 viral
38 nucleic acids of which only coronavirus was positive. the working diagnosis changed to
39 coronavirus fulminant myocarditis with cardiogenic shock and pulmonary infection. The
40 patient was successfully treated with glucocorticoid and human Ig and cTnT decreased to
41 220 ng/L by one week and 21 ng/L by three weeks.
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49 A further mechanism for consideration involves angiotensin converting enzyme 2 (ACE2)
50 which is expressed in myocardial tissue. SARS-CoV-2 binds cells expressing ACE2²¹.
51 Binding of the virus can down-regulate ACE2 intracellular pathways and mediate
52 inflammation and oedema, contributing to respiratory failure²². In theory this could have a
53 potential impact on patients taking ACE inhibitors (ACEi), resulting in greater risk of
54 acquiring COVID-19 infection and increased severity of disease. However, at present the
55 European Society of Cardiology has highlighted a lack of scientific evidence regarding
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3 COVID-19 infection in patients on ACEi or angiotensin receptor blockers, and supports
4 continuation of antihypertensive therapy in patients with confirmed infection (ESC.org).
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10 **Concluding Summary**

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13 The epidemiology of COVID-19 infection is evolving rapidly. As new cases are identified,
14 understanding of clinical and diagnostic presentations is being refined. Cardiac biomarkers,
15 in particular cTn and natriuretic peptides, are commonly elevated in patients with COVID-19
16 disease. As with many other non-ACS pathologies, elevation of cTn is associated with
17 disease severity and poor prognosis. With the fast-moving development of disease
18 progression across the globe and with better understanding of the mechanisms of
19 cardiovascular complications in COVID-19, cardiac biomarkers can be utilised as a metric of
20 a worsening clinical scenario or as an indicator of improving response due to
21 cardioprotective intervention.
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References

1. Kristian G. Andersen, Andrew Rambaut, W. Ian Lipkin, Edward C. Holmes, Robert F. Garry. The proximal origin of SARS-CoV-2. *Nature Medicine*, 2020; DOI: 10.1038/s41591-020-0820-9.
2. Li Q, Guan X, Wu P, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia. *N. Engl. J. Med.* 2020; Jan 29. doi: 10.1056/NEJMoa2001316.
3. Wang W, Xu Y, Gao R, et al Detection of SARS-CoV-2 in Different Types of Clinical Specimens. *JAMA*. 2020; Mar 11. doi:10.1001/jama.2020.3786.
4. Guan WJ, Hu Y, Liang WH, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med*. 2020 Feb 28. doi: 10.1056/NEJMoa2002032.
5. Lippi G, Plebani M. Laboratory abnormalities in patients with COVID-2019 infection. *Clin Chem Lab Med* 2020 March; DOI: 10.1515/cclm-2020-0198.
6. Nguyen JL, Yang W, Ito K, Matte TD, Shaman J, Kinney PL. Seasonal influenza infections and cardiovascular disease mortality. *JAMA Cardiol* 2016;1:274.
7. Corrales-Medina VF, Suh KN, Rose G, et al. Cardiac complications in patients with community-acquired pneumonia: a systematic review and meta-analysis of observational studies. *PLoS Med* 2011;8, e1001048doi.org/10.1371/journal.pmed.1001048.
8. Yu C-M. Cardiovascular complications of severe acute respiratory syndrome. *Postgrad Med J* 2006;82:140–144.
9. Pan S, Zhang H, Li C, Wang C. [Cardiac arrest in severe acute respiratory syndrome: analysis of 15 cases]. *Zhonghua Jie He He Hu Xi Za Zhi* 2003;26: 602–605.
10. Li SS, Cheng C, Fu C, Chan Y, Lee M, Chan JW, Yiu S. Left ventricular performance in patients with severe acute respiratory syndrome: a 30-day echocardiographic follow-up study. *Circulation* 2003;108:1798–1803.
11. Alhogbani T. Acute myocarditis associated with novel Middle East respiratory syndrome coronavirus. *Ann Saudi Med* 2016;36:78–80.

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2
3
4 12. Park KC, Gaze DC, Collinson PO, Marber MS. Cardiac troponins: from myocardial
5 infarction to chronic disease. *Cardiovasc. Res.* 2017;113:1708-1718.
6
7
- 8
9 13. Metkus TS, Guallar E, Sokoll L et al. Prevalence and prognostic association of
10 circulating troponin in the acute respiratory distress syndrome. *Crit Care Med.* 2017
11 October ; 45(10): 1709–1717.
12
13
- 14 14. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel
15 coronavirus in Wuhan, China. *Lancet* 2020;395(10223):497-506.
16
17
- 18 15. Liu Y, Yang Y, Zhang C, et al. Clinical and biochemical indexes from 2019-nCoV
19 infected patients linked to viral loads and lung injury. *Sci China Life Sci*
20 2020;63(3):364-374.
21
22
- 23 16. Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with
24 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA* 2020
25 <https://doi.org/10.1001/jama.2020.1585>.
26
27
- 28 17. Ruan Q, Yang K, Wang W, Jiang L, Song J. Clinical predictors of mortality due to
29 COVID-19 based on an analysis of data of 150 patients from Wuhan, China.
30 *Intensive Care Med* 2020 <https://doi.org/10.1007/s00134-020-05991-x>.
31
32
- 33 18. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult
34 inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet*
35 2020, Mar 11; [doi.org/10.1016/S0140-6736\(20\)30566-3](https://doi.org/10.1016/S0140-6736(20)30566-3).
36
37
- 38 19. Xiong TY, Redwood S, Prendergast B, Chen M: Corona viruses and the
39 cardiovascular system: acute and long-term implications. *Eur. Soc. Cardiol.* 2020 Mar
40 13; [doi:10.1093/eurheartj/ehaa231](https://doi.org/10.1093/eurheartj/ehaa231)
41
42
- 43 20. Hu H, Ma, F, Wei X, Fang Y. Coronavirus fulminant myocarditis saved with
44 glucocorticoid and human immunoglobulin *Eur Heart J*, ehaa190, 2020 Mar 20;
45 [doi:10.1093/eurheartj/ehaa190](https://doi.org/10.1093/eurheartj/ehaa190).
46
47
- 48 21. Wit E D, Doremalen N. V, Falzarano D, Munster VJ. SARS and MERS: recent
49 insights into emerging coronaviruses. *Nat Rev Microbiol* 2016;14: 523–534.
50
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2
3 22. Oudit GY, Kassiri Z, Jiang C, Liu PP, Poutanen SM, Penninger JM, Butany J.
4 SARS coronavirus modulation of myocardial ACE2 expression and inflammation in
5 patients with SARS. *Eur J Clin Invest* 2009;39:618–625.
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Figure Legends

Figure 1: Global utilisation of COVID-19 testing. (Source: <https://ourworldindata.org/covid-testing>).

Figure 2: COVID-19 mortality rate in patients with pre-existing diseases. CRD, Chronic Respiratory Disease; CVD, Cardiovascular Disease. (Data source: Johns Hopkins University Centre for Systems Science and Engineering)

Figure 1:

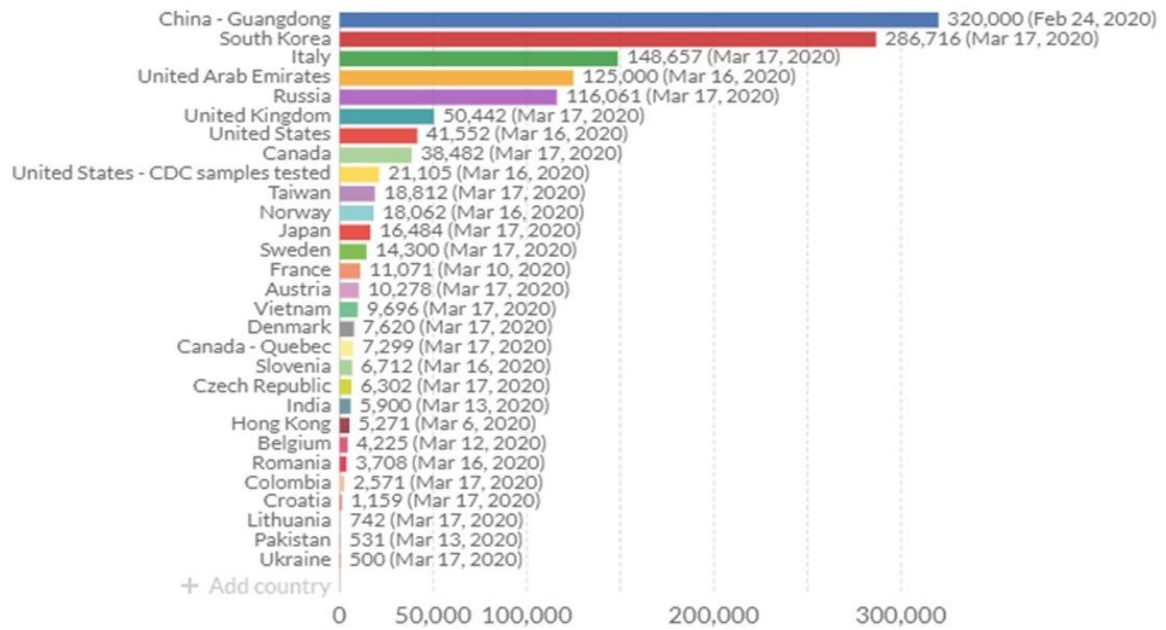


Figure 2:

