Received: 7 October 2021 | Revised: 24 January 2022 | Accepted: 13 February 2022

DOI: 10.1111/pace.14469

PACE WILEY

CASE REPORT

A reproducible sensor pattern to suspect COVID19 pulmonary infection with LATITUDE. Case report and literature review

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Abstract

A 78 year-old patient with postischaemic dilated cardiomyopathy and severely reduced ejection fraction was implanted with a Boston Scientific RESONATE X4 CRT-D and followed by LATITUDE remote monitoring platform. From the end of January to the end of March 2021 he was hospitalized for COVID19 pneumonia followed by two episodes of acute heart decompensation with bilateral pleural effusion. We remotely followed the patient and identified a typical Heart Logic sensor pattern linked to the COVID19 pneumonia, different from the one linked to the heart failure (HF). We eventually made a literature review on the topic.

KEYWORDS
COVID-19, heart failure, heart logic, home monitoring

1 | INTRODUCTION

Severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) has emerged from December 2019 as a new human viral pathogen, which targets the respiratory tract and is responsible of the ongoing global pandemic. Infection with SARS-CoV-2 has a broad range of symptoms: from asymptomatic or mildly symptomatic infection to a bilateral pneumonia with severe respiratory failure,[1,2] that can lead to an acute respiratory distress syndrome. Chronically ill patients, as heart failure (HF) patients, are more likely to develop severe symptoms and a poorer outcome than patients without any comorbidities.[3] As a consequence, remote home monitoring during this period has been critical for patients, in order to avoid unnecessary exposure within the health care system. Many patients with chronic HF have implantable cardiac devices, which can be equipped with physiologic sensors that can be remotely monitored.

2 | CASE REPORT

A 78-year-old male with post-ischaemic dilated cardiomyopathy, 28% left ventricular ejection fraction, left bundle branch block and repeated episodes of HF was implanted with a Boston Scientific RESONATE X4 CRT-D in 2017 and since then he has been followed by LATITUDE remote monitoring system at our center. He also had paroxysmal atrial tachycardias, type II diabetes mellitus, chronic kidney disease, dyslipidemia and arterial hypertension. He started to experience exertional dyspnea and orthopnea without fever and on January 21st, 2021 he was referred to the emergency room of a different center in our city. A chest computed tomography (CT) scan revealed bilateral interstitial alveolar consolidation surrounded by ground glass areas suggestive of COVID19 pneumonia, associated with bilateral pleural effusion. The blood tests showed a mild neutrophilic leukocytosis with a moderate increase of both C-Reactive Protein (CRP) and B-natriuretic peptide (BNP); he was tested positive for SARS-CoV-2 on 23rd January. The patient was treated with parenteral broad-spectrum antimicrobial therapy and diuretic therapy and was then discharged on 27th January with the diagnosis of interstitial COVID19 pneumonia with secondary acute HF. Thereafter on 8th February the patient was re-hospitalised for acute HF. The SARS-CoV-2 nasopharyngeal swab was still positive and the repeated chest CT scan revealed the persistence of bilateral ground glass areas with parenchymal consolidations and moderate pleural effusion. He was treated with oxygen, diuretic and antimicrobial combined with steroidal therapy and discharged on 24th February.

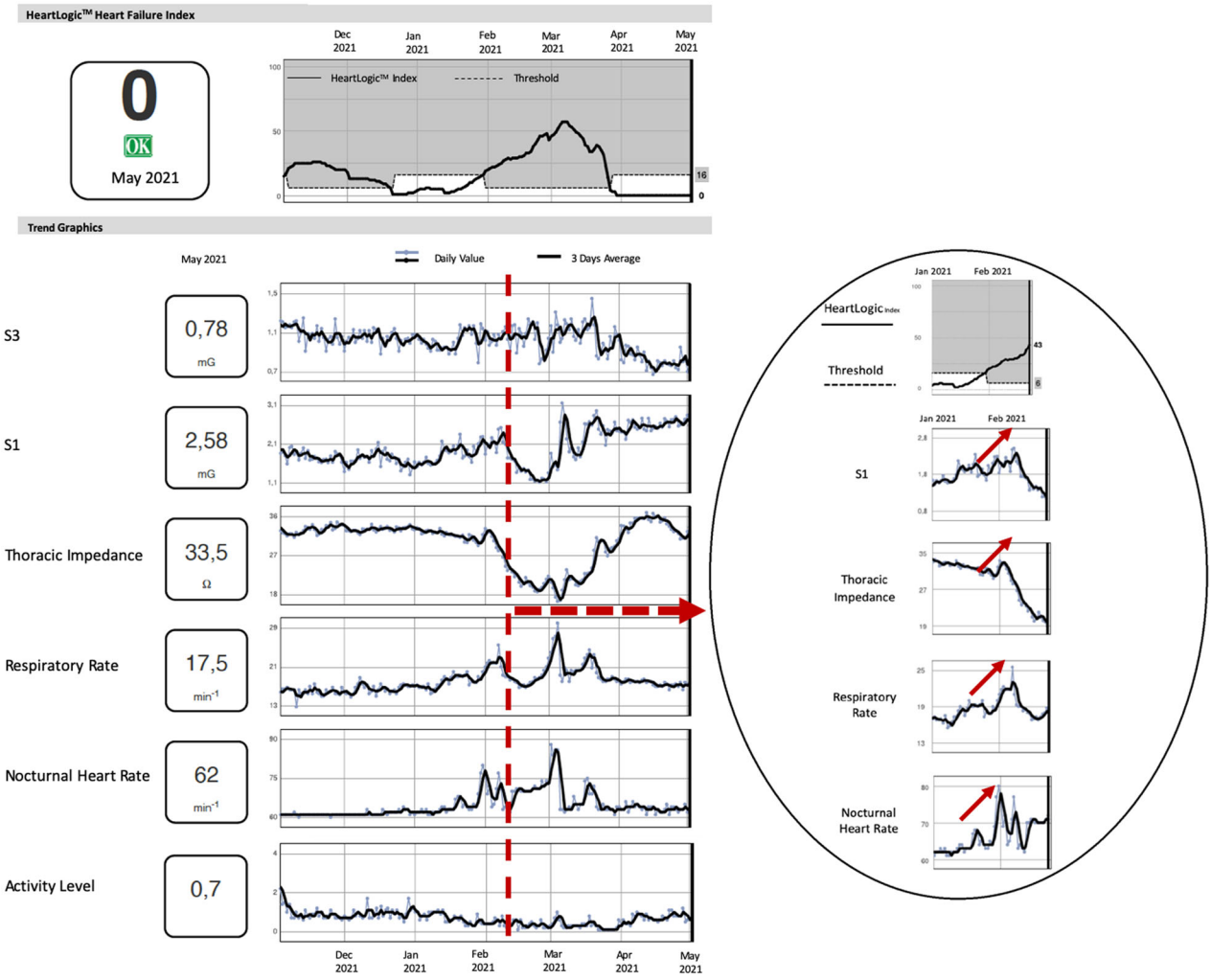

FIGURE 1 Latitude report of COVID-19 positive patient, showing a biphasic pattern: HeartLogic™ sensor pattern related to COVID-19 pneumonia from the end of January until the middle of February; Heart Logic sensor pattern related to the subsequent episodes of heart failure from the middle of February [Color figure can be viewed at wileyonlinelibrary.com]

However, after 1 month he was re-admitted for acute HF with severe bilateral pleural effusion; the pulmonary parenchymal consolidations and ground glass areas were radiologically improved, with worsened bilateral pleural effusion. The patient was treated with loop diuretic therapy and inotropic support and eventually on the 30th of March he was discharged with documented complete resolution of pleural effusion and lung consolidations.

The HL algorithm sent an alert to our center at the end of January. The patient was never admitted to our center, but he was contacted by phone when HL exceeded the alert threshold and then remotely followed. The tracings were then reviewed and associated with the clinical context. As displayed in Figure 1, from the symptoms' onset until the beginning of February an increase in first heart sound amplitude (S1), intrathoracic impedance (ITI), respiratory rate (RR) and nocturnal heart rate (nHR) were identified. Then, S1 and ITI showed a mutual decrease, while RR and nHR had a biphasic pattern. No significant variations were seen in activity level.

2.1 | Discussion and review of the literature

The Heart Logic (HL) is a multisensor HF index and alert algorithm that can predict impending HF decompensation,[4] by combining data derived from multiple sensors: S1 and third heart sound amplitude (S3), ITI, RR, nHR and activity level. The HL algorithm combines all the information into a daily index value which reflects the hemodynamic status of the patient and as it reaches a specific threshold an alert is automatically triggered, in order to allow the clinician to adjust the medical therapy and possibly prevent further HF worsening. In MultiSENSE study,[4] HL algorithm has demonstrated to be a sensitive and timely predictor of impending HF decompensation with a 70% sensitivity to detect impending HF and an unexplained alert rate of 1.47 per patient-year (the study target was < 2 alerts per patient-year). Other algorithms can track ITI changes over time in order to assess pulmonary congestion in HF patients: OptiVol 2.0 (Medtronic)[5] and CorVue (Abbott Laboratories). Even though these technologies seem to be promising, recent

TABLE 1 Review of the literature on published papers describing heart logic algorithm findings during COVID-19 pneumonia in patients with heart failure. Pts patients; HR, heart rate; HF heart failure; RR, respiratory rate; heart logic HL; ND, not defined; RSBI, rapid shallow breathing index; T, temperature

Author	Article type	Journal	Pts Age/Gender	History	Chest CT findings	HL Index	S3	S1	Thoracic Impedance	RR	Night HR	Activity Level	Comments
Bontempi et al.	Case report	Clin case Rep	63/M	COVID-19 pneumonia followed by acute HF	Diffuse ground glass opacities (ratio 60%)	No alert	↓	=	↑	↑	=	↓	During acute HF: ↑HeartLogic Index with ↑night HR, ↑S3, ↓impedance
	2020												
Heggermont et al.	Case report	Case rep in card	72/W	COVID-19 pneumonia	Bilateral multifocal ground glass opacities with partial consolidation	↑ with Alert	↑	↓ then ↑	↑	↑	↑	↓	Also: ↓ HR variability; ↑ average HR; ↓ n. apneas
	2020												
													Timing: 7 days before hospitalization
Yapejian et al.	Case series	EHJ case reports	Case 1: 67/W	SARS-CoV-2 infection	ND	↑ with Alert	ND	=	↑	↑	=	↓	Not hospitalized; ↑ HR 2 days before symptoms; ↑ HL index 2 days after symptoms
	2021												

(Continues)

TABLE 1 (Continued)

Author	Article type	Journal	Pts Age/Gender	History	Chest CT findings	HL Index	S3	S1	Thoracic Impedance	RR	Night HR	Activity Level	Comments
Yapejian et al.	Case series	EHJ case reports	Case 2: 31/W	SARS-CoV-2 infection	Normal chest x-ray	↑ with Alert	↓	=	↑	↑	↓	↓	↑ HL index 1,5 months before hospitalization
	2021												
Yapejian et al.	Case series	EHJ case reports	Case 3: 84/M	SARS-CoV-2 infection	ND	No alert	↓ trend	=	↑	↑	=	↓	Based on RR increase the patient was diagnosed with COVID-19
	2021												
Shumway et al.	Case series	J. Cardiac Fail	Case 1: 62/M	SARS-CoV-2 infection	ND	↑ with Alert	↑	↑	↑	↑	↑	↓	Also: ↑ RSBI; ↑ T
	2021												
				Not hospitalized									
Shumway et al.	Case series	J. Cardiac Fail	Case 2: 67/M	COVID-19 pneumonia	ND	↑ with Alert	↓	↑	↑	↑	↑	↓	Also: ↑ RSBI. HL sensor variations started several days before hospitalization.
	2021												
				Hospitalized									
Shumway et al.	Case series	J. Cardiac Fail	Case 3: 78/M	SARS-CoV-2 infection	ND	↑ with Alert	↓	↑	↑	↑	↑	↓	Also: ↑ RSBI.
	2021												
				Not hospitalized									

data show that sensitivity and accuracy in predicting HF episodes with ITI-based algorithms are variable and that they are not often clinically useful,[6,7] suggesting that ITI alone may not be enough for this purpose.

In our case, as represented in Figure 1, the symptom onset coincided with a mounting increase of HL index, which exceeded the threshold of 16 by the end of January, remained elevated reaching a maximum value of more than 50 at the beginning of March and finally normalized by the end of March. In the previous episodes of HF, all not requiring hospitalization, the HL index of our patient had never reached a value of more than 30. Regarding the HL sensors trend, we can distinguish a biphasic pattern, the first connected to the COVID-19 pneumonia and the other one to the subsequent HF episodes. From the end of January until the middle of February the S1 heart sound, the RR and the nHR were increased, while S3 and activity level didn't show any changes, interestingly the ITI showed an increasing trend. This pattern is in line with the typical COVID-19 HL pattern we found in our literature review. From the middle of February a second pattern emerged reflecting the HF episodes triggered by the pulmonary infection: the ITI fell down to less than 18 Ohm because of bilateral pleural effusion and simultaneously the S1 decreased until 1.1 mG, while RR and nHR remained high and S3 and activity level did not show any changes. It is important to underline the extremely high value of HL index during the HF episodes reflecting the severity of patient's clinical condition. In this particular case, the oral therapy adjustment alone, driven by the home monitoring, was not enough to prevent further HF hospitalizations.

From our review of the literature, we found two case reports[8,9] and 2 case series[10,11] reporting the HL physiologic sensor changes, for a total of eight patients with SARS-CoV-2 infection. As represented in Table 1, the patients were all infected by SARS-CoV-2 and even though only 3/8 patients had a more severe clinical manifestation with pneumonia, in 8/8 patients (100%) an increase in the ITI in association with an increase in the RR and a decrease in the activity level was present. This pattern seems to be related to SARS-CoV-2 infection, as it differs from what happens during impending HF, where a rapid shallow breathing pattern associated with a decrease of the activity level is common,[4] in association with a decrease in ITI, because of fluid overload due to HF.[12] Lung hyperinflation with air trapping[9] can be the reason of the increased ITI in SARS-CoV-2 infection. Heart sounds are also clinical relevant parameters that can vary during HF: S1 is associated with ventricular contraction status[4] and is supposed to decrease during heart acute decompensation; on the other hand S3 reflects the early diastolic filling, and is a pathophysiological landmark of acute HF. In COVID-19 patients heart sounds seem not to have a common pattern, as S1 was increased in 3/8 cases while in 4/8 patients it was not significantly modified and S3 was decreased in 5/8 cases while in 2/8 it was increased. The nHR, considered as an indicator of cardiac status, was increased in 4/8 (50%) cases. Taking together all the sensor information, the HL set an alert in 6/8 patients.

Eventually, Gardner et al.[13] retrospectively compared the HL patterns of changes in three subsets of patients: patients with SARS-CoV-2 infection, HF patients or non-COVID-19 pneumonia patients. Their findings are consistent with our observations: in COVID-19 patients the RR, temperature and nHR were significantly increased, while activity level accordingly fell as compared to patients with HF or non-COVID-19 pneumonia. Interestingly, the ITI was significantly higher in COVID-19 patients as compared only with HF patients; indeed no significant change in ITI was detected when comparing COVID-19 patients to non-COVID-19 pneumonia patients, suggesting an underlying pathophysiological mechanism related to pulmonary infection. The earliest sensor change was the RR, followed by temperature.[13] Furthermore, no significant changes in S1 and S3 amplitude were detected when comparing HF patients to COVID-19 and non-COVID-19 pneumonia patients.[13]

The present case and the literature review show that LATITUDE remote monitoring algorithm may become a useful tool to remotely detect SARS-CoV-2 infection, distinguish it from HF and lead to an early hospitalization for symptomatic patients or to a simple home monitoring.

2.2 | Key clinical message

HL algorithm may be a useful tool to detect non-HF-related decompensation, such as SARS-CoV-2 infection. The most common HL pattern for SARS-CoV-2 infection seems to be an increase in ITI combined with an increase in the RR.

AUTHOR CONTRIBUTION

Simone Zanchi MD and Carmelo La Greca MD drafted the manuscript; all other authors contributed to the critical review of the manuscript.

CONFLICT OF INTEREST

The authors report no conflict of interest regarding this topic.

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How to cite this article: Zanchi S, La Greca C, Di Nanni N, Fogliata E, Zani M, Pecora D. A reproducible sensor pattern to suspect COVID19 pulmonary infection with LATITUDE. Case report and literature review. *Pacing Clin Electrophysiol*. 2022;45:425–430. https://doi.org/10.1111/pace.14469.