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CASE REPORT

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Use of a novel implantable cardioverter-defibrillator multisensor algorithm for heart failure monitoring in a COVID-19 patient: A case report

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Abstract

We report the case of a patient implanted with an implantable defibrillator endowed with a multisensor algorithm for heart failure monitoring. Automatic measurement of multiple clinical variables allowed to detect impending heart failure decompensation and showed its ability to facilitate differential diagnosis in the context of the current COVID-19 pandemic.

KEYWORDS

COVID-19, decompensation, heart failure, prediction, remote monitoring, respiratory disease

1 | INTRODUCTION

The first cases of coronavirus disease 2019 (COVID-19) were reported in December 2019,[1] and rapidly, COVID-19 became a worldwide health emergency. COVID-19 is primarily a respiratory disease, but many patients also have cardiovascular disease. This may be secondary to the lung disease and can be problematic especially in patients with pre-existing heart failure (HF).[2] In order to prevent viral transmission during the COVID-19 pandemic, cardiac implantable device centers are encouraged to adopt remote monitoring systems to limit in-person office visits.[2]

We report the case of a patient in whom an implantable cardioverter-defibrillator (ICD) endowed with an multisensor algorithm for HF monitoring was implanted. We describe data collected from sensors, the combined index, and their association with a COVID-19 respiratory episode and an HF event during follow-up.

2 | CASE REPORT

On 10 March 2020, a 63-year-old man was admitted to the hospital with fever and diarrhea. The patient had a history of nonischemic-dilated cardiomyopathy, left bundle branch block, type 2 diabetes mellitus, hypertension, and hyperthyroidism. In September 2018, he had received a biventricular ICD (model RESONATE X4, Boston Scientific). At the time of the implantation, the left ventricular ejection fraction (LVEF) was 30%. The patient positively responded to cardiac resynchronization therapy, his LVEF increased to 55%, and no events of HF decompensation were reported during follow-up. He was remotely monitored on the LATITUDE (Boston Scientific) platform, and the multisensor HeartLogic diagnostics was enabled. The patient provided written informed consent, and the diagnostic procedures were conducted in accordance with institutional guidelines about the protection of human subjects.

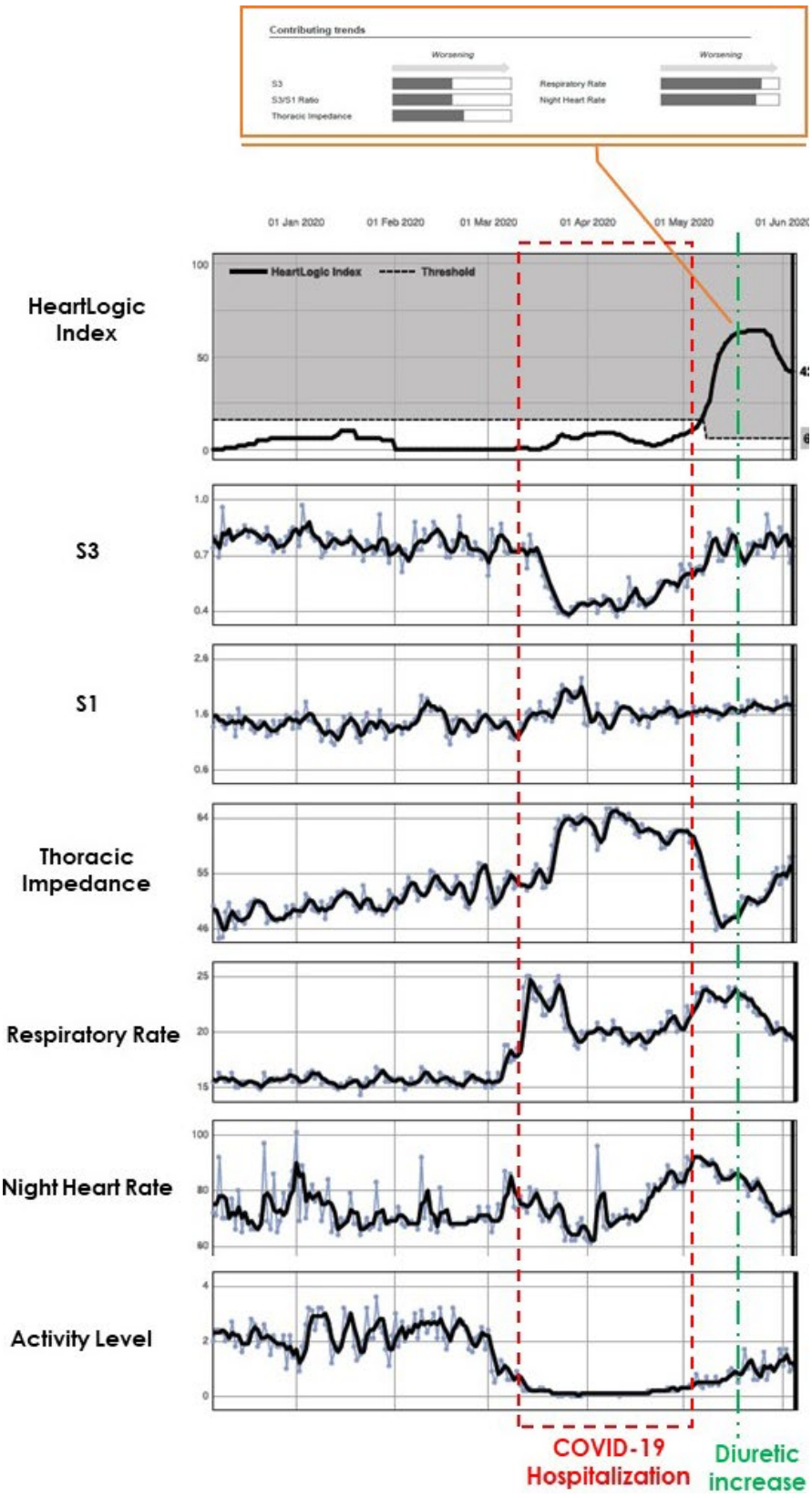

FIGURE 1 Report of automatic diagnostics available for review through the LATITUDE remote monitoring platform. In the box, it is reported the bar graph representing the relative contribution of sensors to the combined HeartLogic Index at the time of the HF event

On admission, the computed tomography revealed bilateral diffuse ground-glass opacities in lungs (ratio 60%) with no pleural effusion. The PaO_2/FiO_2 was 295, and a nasopharyngeal swab was performed with a positive result for SARS-CoV-2. The patient was initially treated with lopinavir/ritonavir in association with hydroxychloroquine. After 1 week, the fever disappeared but the PaO_2/FiO_2 declined to 42. The patient was intolerant for continuous positive airway

pressure; thus, high-flow O_2 with reservoir was initiated. The PaO_2/FiO_2 ratio began to increase around mid-April, and on 19 April, the computed tomography showed a marked reduction of the extension of the bilateral opacities in lungs. The echocardiographic evaluation confirmed a satisfactory LVEF (55%), and the patient was discharged home on 4 May.

On 9 May, the HeartLogic index crossed the threshold (programmed value 16) and an automated notification was sent to the remote follow-up center. On 16 May, the persistence of the alert condition was confirmed at remote data review, and a progressive increase in the combined index was noticed. The main contributing sensors were the heart sounds, the thoracic impedance, the respiratory rate, and the night heart rate (Figure 1). At telephone contact, the patient confirmed the reappearance of dyspnea on exercise and fatigue. The HF medical therapy prescribed at hospital discharge was then assessed and compared with that taken before hospitalization. It included Bisoprolol 2.5 mg, Sacubitril/Valsartan 24/26 mg, Statins 20 mg, Spironolactone 25 mg, and Aspirin 100 mg. The diuretic therapy was found to have been discontinued during the hospitalization, and it was therefore reestablished (Furosemide 25 mg). During the following weeks, an increase in thoracic impedance was noticed, together with a decrease in the respiratory rate and in the night heart rate. The S3 amplitude stabilized, the patient activity slightly increased, and the composite index declined, as detected on remote data review on 4 June. At telephone contact, the patient reported improvement in HF symptoms.

3 | DISCUSSION

In December 2019, an outbreak of pneumonia caused by a novel coronavirus occurred in Wuhan, China.[1] The virus was identified as severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), which leads to coronavirus disease 2019 (COVID-19).[3] The clinical course of SARS-CoV-2 infection is mostly characterized by respiratory tract symptoms, including fever, cough, pharyngodynia, fatigue, and complications related to pneumonia and acute respiratory distress syndrome.[4] Moreover, COVID-19 pneumonia may lead to the worsening hemodynamic status due to hypoxemia, dehydration, and hypoperfusion. In one report, 23% of all hospitalized patients developed HF, while HF prevalence was significantly higher in fatal cases compared with survivors.[5]

The ESC Guidance for the diagnosis and management of cardiovascular disease during the COVID-19 pandemic[2] suggests that ambulatory stable HF patients should refrain from hospital visits and strongly encourages centers to consider telemedicine to provide patients medical advice and follow-up, in order to prevent viral transmission to patients and healthcare providers. These recommendations specifically apply to patients with cardiac implantable devices. For them, in-person office visits should be replaced by remote contact, using the device information obtained through remote monitoring. Modern cardiac devices continuously monitor the integrity of the implanted device, as well as measure clinical variables, thus potentially providing early warning of safety issues or changes in clinical status. Many studies have investigated the ability of ICD diagnostics to identify patients at risk of HF events, with contradictory results.[6,7] In the Multisensor Chronic Evaluation in Ambulatory Heart Failure Patients (MultiSENSE) study,[8] a novel algorithm for HF monitoring was developed in accordance with the hypothesis that combining multiple physiological sensors that evaluate different aspects of HF physiology would be superior to monitoring a single sensor. The HeartLogic index combines data from multiple ICD-based sensors (third heart sound amplitude (S3), third/first heart sound amplitude ratio (S3/S1), thoracic impedance, median respiratory rate, ratio of respiration rate to tidal volume (rapid shallow breathing index), and night heart rate) and has proved to be a sensitive and timely predictor of impending HF decompensation. On a daily basis, the algorithm evaluates changes in multiple trends from the patient's own baseline. The sensor changes are aggregated and weighted by the individual's daily risk for HeartLogic index calculation. The patient's baseline is also updated gradually over time so that it continues to reflect a relevant reference measurement for the patient. An alert is issued when the combined index crosses a programmable threshold.

In the present case, we did not notice any change in the HeartLogic index at the time of the patient admission for suspected COVID-19. Indeed, at that time the only change in recorded sensors was a marked increase in the respiratory rate, followed by a decrease in the patient activity. These changes became increasingly evident during the first period of the hospital stay, closely correlating with the worsening of respiratory function and the immobility of the patient. The respiratory function began to improve in mid-April and was preceded by a decrease in the ICD-measured respiratory rate. These changes were accompanied by a reduction in the amplitude of S3, usually related to an improved diastolic function,[9,10] and an increase in the thoracic impedance, a sign of reduction in thoracic fluids.[11] Upon reaching adequate respiratory function and after verification of adequate hemodynamic compensation, the patient was discharged. Nevertheless, the trends of the ICD-measured parameters were already showing a progressive increase in the amplitude of S3, accompanied by an increase in the night heart rate, possibly indicating an impending HF decompensation. Following discharge, there was also a subsequent further increase in respiratory rate accompanied by a sharp drop in thoracic impedance. All these changes resulted in the increase in the combined HeartLogic index that crossed the threshold and triggered the remote alert. The alert occurred after discontinuation of the diuretic therapy and the combined index recovered when the discontinued

diuretic therapy was reestablished. Interestingly, at the time of the COVID-19-related respiratory episode, the composite index did not trigger any alert. Indeed, the HeartLogic algorithm was developed to diagnose HF events, and the index increases only when multiple contributing trends suggest a worsening cardiac condition.[8] However, the ICD measurements of respiratory function clearly identified an ongoing event. The respiratory parameters also changed at the time of the impending HF event, but only after the modification of other indexes more closely related to the cardiac function, that is, the heart sounds. Since these sensors were dramatically altered during the COVID-19 hospitalization and some of them, such as S3, seemed to substantially return to prehospitalization levels during the alert, one may hypothesize that the alert was driven by signal changes reflecting pulmonary function recovery rather than worsening HF. However, other sensors such as impedance, respiration, and night heart rate were worsened relative to prehospitalization levels. This seems to suggest that in this case, the clinical event had a cardiac origin. As previously described,[12,13] the HeartLogic alert diagnosed an impending HF event before signs or symptoms occurred, it early detected discontinuation of the HF therapy and allowed to reestablish it promptly.

In the COVID-19 era, even in the case of patients already admitted to the hospital, providers may be distracted from other diagnoses and appropriate care may be delayed.[14] In the case of HF patients followed through remote monitoring, the differential diagnosis may be even more challenging, since COVID-19 with acute respiratory distress syndrome can mimic exacerbation of HF. Thus, the ability to continuously monitor multiple variables, including indexes of respiratory function, may be particularly relevant for HF patients during the COVID-19 pandemic.

4 | CONCLUSIONS

Modern ICDs continuously monitor multiple physiological variables to identify patients at risk of HF events. In the present case, the HeartLogic algorithm confirmed its ability to detect impending HF decompensation and to enable early management. Monitoring of multiple clinical variables (eg, respiratory rate and volume, thoracic impedance) may also facilitate screening, triage, and differential diagnosis in the context of the current COVID-19 pandemic.

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CONFLICT OF INTEREST
C. Nozza, M. Campari, and S. Valsecchi are employee of Boston Scientific Italia. All the remaining authors have no major conflicts of interest to disclose.

AUTHOR CONTRIBUTIONS
LB and MC: wrote the paper. FS and DF: provided critical feedback. CN, MC, and SV: aided in interpreting device data and in reporting algorithm details. AC: supervised the work. All authors discussed the results and commented on the manuscript.

ETHICAL APPROVAL
The patient provided written informed consent for data storage and analysis.

DATA AVAILABILITY STATEMENT
The data can be shared on reasonable request to the corresponding author.

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