Intra-cardiac microcomputer allows for innovative telemedicine in chronic heart failure during coronavirus disease-2019 pandemic: a case report

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Background
Heart failure patient management guided by invasive intra-cardiac and pulmonary pressure measurements through permanent intra-cardiac micro-sensors has recently been published as a strategy to individualize the therapy of patients with chronic heart failure to reduce re-hospitalization and optimize quality of life. Furthermore, the use of telemedicine could have an important impact on infective disease spread during the current coronavirus disease-2019 pandemic.

Case summary
Emergent hospitalization of a patient with acute on chronic heart failure, who is currently in self-isolation as a result of his comorbid profile that exposes him to high risk for severe course and mortality in case of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection was prevented using a last generation telemedicine tool.

Discussion
Further implementation of invasive telemedicine could prevent hospitalization for acute decompensated heart failure and consecutive exposure to a potential hospital infection with SARS-CoV-2 in high-risk patients.

Keywords
Case report • COVID-19 • SARS-CoV-2 • Heart failure • Telemonitoring

Learning points
• Chronic heart failure (CHF) is the leading cause of hospitalization among adults and elderly in industrialized countries.
• Coronavirus disease-2019 pandemic enforces to rethink the management of CHF patients, who are at particular risk of infection when treated within hospital premises, as well as severe course in case of infection.
• Clinicians should be aware of the progress of home-monitoring technologies for heart failure patients, making them a potential tool to avoid recurring hospitalizations for this group.
Introduction

Coronavirus disease-2019 (COVID-19) has developed into a worldwide pandemic after the report of the first severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in December 2019 in the Chinese region of Wuhan.\(^1,2\) As of 10 June 2020, Johns Hopkins University has reported more than 7 250 000 confirmed cases with numbers increasing daily. Age, hypertension, diabetes, coronary heart disease, and cerebrovascular disease have been identified as risk factors for critical disease course and mortality in adult patients with COVID-19.\(^3\) Many countries and regions have decided to impose lockdowns in order to protect this patient groups and to consecutively relieve the partially collapsing healthcare systems. High-risk patients were explicitly asked to maintain self-isolation and to avoid any potentially infectious contacts. Emergency departments and hospital wards, as well as doctor’s offices, represent high-risk areas for infection with SARS-CoV-2 due to the fact that COVID-19 patients are actually treated there. In this context, chronic heart failure (CHF) has an estimated worldwide prevalence of over 37.7 million people, and is associated with significant morbidity, being the leading cause of hospitalization among adults and elderly in the industrialized world. Defining specific strategies to reduce the risk of re-hospitalization secondary to exacerbation of CHF through the use of monitoring devices could be an important step to contain the spreading and lethality of COVID-19.

Timeline

| Time                | Event                                                                                                                                 |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 15 August 2019      | Implantation of a permanent left atrial pressure (LAP) sensor (V-LAP system, Vectorious Medical Technologies, Tel Aviv, Israel)            |
| December 2019       | First severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections are confirmed in the Chinese region of Wuhan               |
| 18 March 2020       | Patient begins strict self-isolation due to coronavirus disease-2019 spread in Germany after his attending physicians classified him as a high-risk patient for severe course and mortality in case of SARS-CoV-2 infection |
| 25 March 2020       | An increasing LAP is documented through online data display in the patient. The patient is contacted by phone for further anamnesis immediately |
| 26 March 2020       | After further confirmation of increased LAP, the dosage of oral diuretics is increased by phone. The patient is contacted on daily bases to report on symptoms. |
| 27–29 March 2020    | Left atrial pressure decreases. Patient reports no further symptoms.                                                                       |

Case presentation

A 68-year-old male with CHF based on three-vessel coronary artery disease leading to ischaemic cardiomyopathy with impaired left ventricular ejection fraction (= 30%) presented to our emergency department with shortness of breath, severe oedema of the lower legs, and fatigue. Examination showed tachypnoea (28/min), oxygen-saturations of 90% on air with bilateral rale at lungs base in auscultation and a blood pressure of 106/68 mmHg. An electrocardiogram detected Sinusrhythm with 88 b.p.m. while chest-X-ray revealed pulmonary congestion, as well as bilateral pleural effusion.

The patients complex comorbid profile included Type II diabetes mellitus, paroxysmal atrial fibrillation, peripheral artery disease, as well as chronic obstructive pulmonary disease.

NT-proBNP (21.548 ng/L) and creatinine (1.84 mg/dL) were significantly increased at admission, with no further relevant abnormal findings in laboratory values at admission. A 7 days inpatient treatment with i.v. diuretics, administration of oxygen and blood pressure modulation led to discharge with complete cardiac compensation.

Due to recurrent hospital admission for decompensated heart failure, the patient was implanted with a new generation permanent left atrial pressure (LAP) sensor\(^7\) (V-LAP system, Vectorious Medical Technologies, Tel Aviv, Israel, Figures 1 and 2) in August 2019. Since then, he has performed daily measurements of his LAP using an external companion device (thoracic belt) (Figure 3), which subsequently transfers the measured LAPs to a telemonitoring hub. The attending physicians routinely evaluate the transmitted data (Figure 4). From 24 March to 26 March, a consistent increase of LAPs has been observed through online monitoring and, consequently, the patient has been telephonically contacted to confirm his clinical...
status. He has then reported a slight increase in physical exhaustion and has denied additional signs and symptoms of acute on CHF.

The patient has been instructed to perform a last LAP measurement, confirming an increased LAP (33.3 mmHg) (Figure 2). Self-measured body temperature was 36.9°C. The patient has reported neither respiratory nor gastrointestinal and/or urogenital infection symptoms. A self-measurement of the brachial blood pressure has revealed stable values of 115/72 mmHg, with a heart rate of 78 b.p.m. In addition, the patient has reported a gain in body weight of 1.1 kg over the last 10 days.

After detailed evaluation of the anamnestic findings as well as the measured data, the patient has been telephonically instructed to increase the daily dose of oral diuretics (torasemide) from 15 mg in the morning and 10 mg at noon to 20 mg twice/day.

The following day compliance and correct intake of the modified drug dose have been telephonically re-assessed. The daily measurements of LAPs in subsequent follow-up have shown an adequate decline to a stable range for this patient. The patient has reported achievement of satisfying physical activity within 6 days after the increase of oral diuretic therapy. In the meantime, the patient has maintained a regimen of self-isolation that had been previously recommended to prevent the treacherous risk of SARS-CoV-2 infection and, in this highly comorbid patient, the consequent development of a complicated and possibly lethal coronavirus disease (COVID-19).

The patient remained asymptomatic with no signs of acute on CHF. Left atrial pressure remained within the desired range and no further changes were made to the therapy. In addition, the patient did not report symptoms of SARS-CoV-2 during telephone follow-up and the body temperature remained within physiological range.

**Discussion**

Randomized controlled trials investigating the use of non-invasive telemedicine systems designed to remotely monitor patients with CHF have failed to demonstrate a clear reduction in hospitalization rates so far. In fact, the telemedicine systems mostly adopted in CHF management make use of surface and wearable devices measuring parameters that normally change only in a later phase of CHF exacerbation. There is clinical evidence showing that pulmonary and intra-cardiac pressures increase up to several weeks before the onset of acute on CHF symptoms. Although the CHAMPION trial showed efficacy of an implantable pulmonary artery pressure sensor to manage CHF patients at risk for CHF re-hospitalizations, having direct measurements of left heart pressures adds sensitivity in patients affected with CHF and with additional cardiac conditions. In this way, the appropriate treatment can be optimized and carried out quickly, anticipating the onset of symptoms and preventing hospitalizations for exacerbation of CHF. This strategy can, at the same time, provide relief to overloaded emergency departments, intensive care units, and doctor’s offices and protect patients and healthcare providers from potentially infectious situations, like for example the one presently existing as result of the COVID-19 pandemic and others presenting annually during recurring seasonal pandemics (i.e. flu).

According to the inclusion criteria of the ongoing “VECTOR-HF trial” (EUDAMED—CIV-18-05-024064; BfArM—94.1.10-5660-11387), individuals qualifying for an implantation of the device used in the present case are all CHF patients with NYHA-class III, left-ventricular ejection fraction >15% (including (heart failure with preserved ejection fraction)HfPEF) and at least one hospitalization due
Telemonitoring care chain: after implantation of the permanent left atrial pressure sensor (V-LAP system, Vectorious Medical Technologies, Tel Aviv, Israel) and in-hospital patient training, left atrial pressure measurements are performed daily using an external thoracic belt. Data gathered by the belt is automatically transmitted to a central data hub which displays the information to attending physicians that enter the platform via a password-protected individual account. In case of relevant alteration of left atrial pressure, the patient is contacted by phone and drug therapy is adjusted. Effects are then monitored through further left atrial pressure measurements.
to acute decompensation within 12 months before implantation, irrespective of CHF origin. While the inclusion criteria are increasingly expanded in the further course, atrial septal defect (ASD) as well as a previously implanted ASD-Occluder will remain absolute contraindications.

In synthesis, as a result of the present pandemic, an exponential acceleration of the demand for digital transformation may radically change society. In fact, as a consequence of the worldwide lockdown, over 4 billion people are experiencing new ways of performing their daily activities for example through home-working and distance-learning platforms. In this context, healthcare users and providers will possibly increase their appreciation and demand for a healthcare system based upon the most advanced tools for remote monitoring, diagnosing, and treatment.

Another relevant long-term aspect of telemonitoring in CHF could be cost reduction. At present, the device implantation and follow-up care are free of charge for the clinic, health insurance companies, and the patient as part of the trial.

To make telemonitoring of CHF patients sustainable, costs should not be higher than those of frequent hospitalizations for acute heart failure treatment. Patients included in the trial from our centre had an average of four admission for decompensated heart failure per year, implying costs of \( \sim 12,000 \text{ euro} \) in the German healthcare system.

While the price of the implantation will amount around 15,000 euro, cost effectiveness could be reached within the first 2 years after implantation if telemonitoring accomplishes to significantly reduce the hospitalization of CHF patients and a reasonable refund for the attending physicians can be agreed on. Monitorization can be conducted by every attending physician while alerts and recommendations will be sent online automatically by the system.

The social, medical, and economical crisis caused by the COVID-19 pandemic could force us into promoting a more rapid amelioration and adoption of the presently slowly developing possibilities of telemedicine, wearable, and body-embedded technology with the aim of achieving risk reduction, efficiency improvement, and cost sustainability during the provision of care.

**Conclusion**

Constant telemonitoring of LAP and adjustment of medication has prevented possible decompensation of CHF and consecutive hospitalization in a patient who is currently in self-isolation as a result of his comorbid profile that exposes him to high risk for severe course and mortality in case of SARS-CoV-2 infection. The current pandemic reveals the importance of intensified use of digital infrastructure and

![Figure 4 Left atrial pressure online data display (Vectorious Medical Technologies, Tel Aviv, Israel). (A) Left atrial pressure trend before and after adjustment of oral diuretic medication; (B) left atrial pressure curve during measurement on 13 March 2020, last measurement before adjustment of oral diuretic medication. LAP = left atrial pressure.](image)
technical development for medical purposes and patient care, as well as the need for expansion of qualified human resources for telemedicine, in order for it to become an essential cornerstone in future medical and social exceptional and ordinary situations of most kinds.

Lead author biography

Sebastian Feickert, 30 years old, received his MD from the Medical University of Vienna after studying in Vienna, Austria; Hamburg, Germany; and Liverpool, UK. Dr Feickert is currently completing his residency in cardiology and intensive care medicine in Berlin, Germany. His research interests focus on rhythmology, as well as device-supported monitoring and telemedicine.

Supplementary material

Supplementary material is available at European Heart Journal - Case Reports online.

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

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