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Telemedicine in Chronic Diseases: the Time of Maturity with Telemedicine 2.0 in the Setting of Chronic Heart Failure and Diabetes Mellitus!

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Opinion

The rising prevalence of chronic diseases, e.g. chronic heart failure (CHF) and diabetes mellitus, combined with population aging now represents a very real problem for public health [1]. The cost of these chronic diseases has rocketed, and is estimated at several billion dollars in developed countries. What's more, these patients are often elderly and have one or more chronic diseases, and their management is a challenge for healthcare professionals. Thus, 30-50% of elderly patients with type 2 diabetes (T2D) suffered from heart disorders and 30-50% of CHF patients are diabetic [1]. Their needs eat up large amounts of medical resources, just as a shortage in the time careers can provide is beginning to be felt, with medical deserts and a lack of access to healthcare professionals, among other problems. Thus, our societies must "reinvent the medicine of today and also of tomorrow"! Despite the advances in treatment of recent years, most chronic pathologies remain serious diseases in terms of their functional or survival prognosis, and morbidity and mortality are high [1]. This applies for example to CHF, in which the mortality rate of patients with stage NYHA III-IV is at least 30% at 5 years in more recent studies. CHF as diabetes mellitus patients frequently present for emergency hospitalization and re-hospitalization, which impairs the quality of their life. Some of these hospitalizations could be avoided if patients took greater responsibility for their disease and were followed up better. This last point has been particularly well documented in the two pathologies. Telemedicine may be of aid in this setting. Indeed it may even optimize the management of such chronic diseases, particularly by preventing emergency and repeat hospitalizations [2]. It may also make it possible to structure integrated care pathways.

Since the beginning of the 2000's, numerous telemedicine projects have been conceived and developed in the area of CHF [3-21]. Practically all of them have investigated telemonitoring (or tele management, as it is also known) with a focus on CHF patients. The results of those telemedicine projects differed from study to study and were fairly inconclusive regarding any potential clinical benefit in terms of, for instance, re-hospitalization or a decrease in morbidity and mortality. Nevertheless, several reviews and meta-analyses seem to have shown an undeniable utility for telemedicine. Moreover, aside from the medical considerations, it is worth noting that all the studies seem to agree that using telemedicine solutions in the management of heart failure was at least economically beneficial. Depending on the study, the savings were calculated to be between $5000 and more than $50,000/year/patient depending on the stage of heart failure and the setting of the

study. It is worth bearing in mind that those projects, particularly the earlier ones, more closely resembled telephone follow-up with care providers (such as a nurse) traveling to the patient's home, rather than telemedicine as we think of it nowadays with nonintrusive, automated, smart telemonitoring using remote sensors via modern communication technology or even artificial intelligence [18]. Hence in our opinion those studies represent the first generation of telemedicine projects: "telemedicine 1.0" [18].

Over the last 4 to 5 years, a second generation of projects has emerged in the heart failure area, particularly in developed countries [18]. These projects are known as "telemedicine 2.0", because they utilize the new Information and Communication Technology (ICT) and the web. Most of these projects rely on the usual connected tools for monitoring heart failure, such as blood pressure meters, weighing scales, and pulse oximeters, which relay the information collected via Bluetooth, 3G or 4G and incorporate tools for interaction between the patient and healthcare professionals like telephone support centers, tablets, and websites [18]. Some of them also provide tools for motivation and education, and occasionally, questionnaires about symptoms, such as dyspnea, palpitation and edema as experienced by the patient.

The E-care telemonitoring project developed in France falls under this category of "telemedicine 2.0" [22,23]. It has been developed to optimize the home-monitoring of CHF patients. It detects situations in which there is a risk of cardiac decompensation and re-hospitalization, and it does this via a telemonitoring 2.0 platform. The E-care platform generates indicators of a worsening of the patient's cardiac failure status. Between February 2014 and April 2015, the E-care platform has been used in 175 patients with chronic diseases, mainly CHF (more than 60% of the included patients) and T2D (30%) [24]. During this period, the E-care platform was used on a daily basis by patients and healthcare professionals in the Strasbourg University Hospital (Strasbourg, France) according to a defined protocol of use specific to each patient. The mean age of these patients was 72 years and the ratio of men to women was 0.7. The patients suffered from multiple concomitant diseases and had a mean Charlson index of 4.1. During the study, 1500 measurements were taken, which resulted in the E-care system generating 700 alerts in 68 patients. Analysis of the "warning alerts" showed that the E-care platform automatically and non-intrusively detected any worsening of the CHF status of the patients, with: sensitivity, specificity, and positive and negative predictive values, respectively of 100%, 72%, 90% and 100%. Both the healthcare professionals and all the patients used the E-care system without difficulty until the end of the study. During the study of non-autonomous patients, the system was employed by a nurse in addition to other tasks like washing and administering medication, as well as by close ones and family members. Hence, it has been our experience that age is not a limiting factor on grasping and using new technologies. Several recent studies have reached the same conclusion, documenting the use of telemedicine solutions even among 80-year-olds [25].

Diabetes is another field of priority investigation of telemedicine in France, outside the CHF. Innovative projects are being developed or deployed, such as the PLASIDIA platform, run by the European Center for the Study of Diabetes [26]. It is in this setting, we developed an up graduate version of the E-care platform to follow patients suffered from diabetes mellitus under the DIABETe project.

The new version of the E-care platform should be deployed in "complex diabetic" patients; e.g. diabetic patients with high cardiovascular risk or diabetic patients treated with multiple injections [27]. The objective of the DIABETe project is to detect early the risk of hospitalization of diabetic patients with a very high cardiovascular risk: personal history of stroke, IDM, amputation and cardiomyopathy, with intensive insulin therapy (minimum of 3 injections per day or pump), through a personalized follow-up and accompany the patient in the knowledge of his illness and his management. This population is interesting because it allows targeting poly-pathology and poly-medication. It requires global support. It represents 50% of diabetics hospitalized in Diabetology and Internal Medicine. Apart from cardiovascular complications (IDM, PAO, etc.), they are also hospitalized for hypoglycemia, imbalance of diabetes, iatrogenic, infections, etc. [27]. The DIABETe project is based on an intelligent platform that will assist the medical profession by automating the processing of information from non-intrusive medical sensors (blood glucose meter, blood pressure monitor, actimeter, connected scale, etc.) as well as subjective information from the patient himself (questionnaires) and its behavior (compliance) to detect and report these situations at risk of hospitalization early. Therapeutic education tools adapted to the patient and the situation will be made available to the individual. Communication to the subject will be provided by a touch pad. Alerts testifying to a deterioration of the patient's condition will be generated by artificial intelligence and reported to health professionals in charge of the patient, to anticipate the decompensation and to afford the means of care outside the emergency setting. These solutions, derived from new technologies, will be innovative and original to offer the best acceptability by patients. It will allow the sharing of medical data between health professionals as part of a city-hospital network. Ultimately, it should also lead to an improvement in the quality of life of the patient.

DIABETe does not compete with Diabeo or other expert systems whose purpose is to optimize the glycemic balance, which in itself is one of the essential objectives of diabetes mellitus [28]. The DIABETe project aims at "global" management of the diabetic patient through the detection of situations at risk of hospitalization: infection, cardiac decompensation, diabetic foot, etc. but also of course hypoglycemia and hyperglycemia

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leading to hospitalizations. It should also be noted that the remote monitoring platform used in DIABETe is likely to integrate or interface with expert systems such as Diabeo. As a reminder, the Diabeo application, carried by SANOFI, was tested as part of the Télésage clinical trial for 700 patients with DT1 and DT2, under a basal bolus regimen (multi-injection or pump) [28]. The main criterion of the Télésage study is the variation of HbA1c (glycemic control) at one year. A previous study, Télédiab1, conducted between 2007.

The telemedicine 2.0 platform is also capable of structuring the patients' care pathways, a major theme in medicine for our governments and authorities; it is also capable of providing a means for the various healthcare professionals to exchange with each other; and of facilitating access to medical resources. With this in mind, an enhanced version of the E-care platform will be experimented in the homes of heart failure patients as part of a project called PRADO INCADO. PRADO is a French program to support patients returning home after hospital, while PRADO INCADO will specifically target heart failure patients in this setting with the support of the E-care plateform. The project is being run by a group bringing together Strasbourg University Hospital, the Alsatian Regional Health Agency, the Bas-Rhin branch of France's National Health Insurance, and the company PREDIMED Technology. This experience may lead us to witness the birth of the medicine of tomorrow. In the field of chronic diseases, given the epidemiology and expected shortage of time careers can provide, what we need is better follow-up and better education, improved prevention and anticipation, but, above all, better selection of the patients whose use of the healthcare system will be indispensable.

Conflicts of Interest

The authors state that they have no conflicts of interest to declare except Mr M. Hajjam, who is the science director of the company PREDIMED Technology.

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