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Assessment of Patient Perceptions About Web Telemonitoring Applied to Artificial Pancreas Use at Home

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Abstract

Patients with chronic diseases as well as health care systems could benefit from telemedicine applications such as remote monitoring (RM). RM relies on a device that sends patients' health data to a remote server accessible by care teams. Recent smartphone-based artificial pancreas (AP) systems collect comprehensive set of information and could therefore support the development of RM applied to diabetes. To better understand how RM could be integrated in future AP systems, we wanted to get patients' opinion on this concept, as they are the final users of these systems. An online questionnaire with 11 items was sent to 20 experienced patients who tested AP and RM during our recent outpatient studies in France and Italy. We received 17 answers. All patients considered that during their participation in trials, RM was useful, reassuring, and essential. One-third wouldn't have participated without it. When AP is commercialized, 88% of respondents think that AP should go with a RM tool, but it should be activated only at certain times, at first use or in case of difficulties (82%). Participants ask for technical support when a device fails (88%) and for medical help in case of prolonged hyperglycemia (65%) or severe or repeated hypoglycemia (53%), but not after each case of hypoglycemia (6%). More than 75% think that RM could help them to improve their blood glucose control. This preliminary work indicates that patients expect RM to be part of future AP development. Larger studies remain to be performed to investigate its usefulness and potential economic effectiveness.

Keywords

artificial pancreas, remote monitoring, telemedicine, type 1 diabetes, questionnaire

Among the various proposals that intend to improve care dedicated to the patients with chronic diseases, telemedicine appears as a promising option because it could provide health benefits by allowing more frequent interactions between the patient and the care team without increasing time spent for outpatient visits. Remote monitoring (RM) of the patient is a needed component of this approach. RM generally relies on a device, which is daily worn or used by the patient to capture health data and able to transmit them to a remote database, itself being accessible to authorized parties for patient care delivery. The transmission process can be performed in real time or at regular intervals. The care team can then intervene to provide advices to the patient to prevent harmful events and/or improve disease control.

Various kinds of RM systems have already demonstrated their effectiveness, for example, in patients treated by pacemakers, and some of them are used in common practice.[1-3] In type 1 diabetes mellitus, despite the increasing number and variety of devices used every day by the patients—blood glucose meters, insulin pumps, continuous glucose monitors—and the needed target of tight control,[4] RM systems are still limited to investigational use.[5-7] Their potential outcome is, however, quite relevant since RM could help increasing communication between patients and diabetologists to optimize insulin therapy more intensively than the usual quarterly face-to-face visits.[8] A recent randomized study evaluating Diabeo system—a patient logbook on a mobile phone including a software for immediate advice delivery, and also coupled to a website allowing medical information—showed that telemonitoring is able to reduce significantly HbA1c after 6 months of use.[9] Combined with teleconsultations, such systems could even be cost-effective compare to usual health care.[10]

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The emergence of the concept of smartphone-based artificial pancreas (AP) could further support the development of RM applied to diabetes. Indeed, an advanced platform like the Diabetes Assistant (DiAs) device developed at the University of Virginia is able to collect automatically a wide range of parameters and includes wireless network capacities.[11] Thanks to an embedded telemonitoring component, the care team could access a comprehensive set of medical and technical information, allowing increased safety and effectiveness in the adjustment of closed-loop insulin delivery. Such a scenario has been tested during recent outpatient trials performed by our research team.[12-15] Two telemonitoring applications have been developed, 1 as part of the AP@home European project[16,17] and 1 designed for JDRF-funded projects in AP Initiative.[18] Both have been used in pilot outpatient AP trials allowing clinical teams to remotely monitor AP in real time for safety purpose.

Before going further and considering future usages of telemonitoring in AP development for outpatients, we wanted to get patients' opinion on the concept of being telemonitored to get a better understanding of how it could be integrated in AP management. Patients are indeed final users of these advanced systems, and it is very important to understand their perceptions, needs, and wishes to design a tool that could eventually help them in their daily life without bothering them.[10] To collect their views about the possibility to be remotely monitored while using AP, we built a questionnaire and sent it to a series of patients who were already familiar with DiAs and telemonitoring concept. Their answers are presented in this article.

Methods

Participants

Patients were recruited at Montpellier University Hospital (France) and at the University Hospital of Padova (Italy) in September and October 2013. We included adult patients with type 1 diabetes who already tested the AP linked to a telemonitoring system. All participating subjects used DiAs platform for at least 40 hours as part of outpatient clinical studies performed during the past 2 years.[12-14] The concept of telemonitoring was explained to patient by the study team before and during trials. Patients were informed that data collected by DiAs were sent to a remote server so that blood glucose, insulin, and AP parameters would be monitored in real time by the clinical staff. Even if 2 different RM systems were used, subjects couldn't detect any difference, as DiAs user interface remained the same for both systems. Changes were visible only by study teams, which had access to different remote applications.

Questionnaire

Each participant was asked to review and complete an online questionnaire titled "Telemonitoring and Artificial Pancreas." The questionnaire consisted of 11 questions divided in 3 parts: 2 questions were related to patients' recent experience with the system, 7 questions assessed their vision about the evolution of telemonitoring, and the final 2 questions aimed at collecting personal details such as age and technology usage in daily life. The questionnaire was initially written in English and reviewed by the investigators at both clinical sites. It was then translated into French and Italian and reviewed by local teams. Answers were collected anonymously through Google Docs forms.

Table 1. Participants' Age Groups and Common Usage of Technology.

Are you using?	Never	Every week	Every day
A computer (%)	0	6	94
A smartphone (%)	24	0	76
A tablet (%)	53	12	35
20-30 years old (%)		18	
30-40 years old (%)		29	
40-50 years old (%)		29	
50-60 years old (%)		18	
>60 years old (%)		6	

Results

Characteristics of the Survey Population

A total of 20 patients was contacted. We received 17 answers, 8 from Montpellier, and 9 from Padova patients. A wide age range, from 20 to 70, was represented. Except 1 patient, all participants mentioned they use a computer every day, and 3 out of 4 were daily smartphone users. About half of respondents used a tablet at least once a month. No noticeable difference was observed between answers from Italian and French patients (Table 1).

Back on Patient AP Experience

The first part of the questionnaire focused on patients' recent experience with AP and telemonitoring. All patients considered that during the clinical trial, the telemonitoring tool used by the study staff was useful (88% a lot or extremely, 12% moderately), reassuring (82% a lot or extremely, 18% moderately), and even essential (76% a lot or extremely, 24% moderately).

Of note, telemonitoring seems to be as important as the study staff itself. Indeed, about one-third of subjects wouldn't have tested AP without the presence of the medical staff and the same proportion wouldn't have participated in the study without the telemonitoring tool (Table 2).

Views on Telemonitoring

Patients were then asked to give their opinion about the future use of telemonitoring for AP development and about the features that should be included (Table 3).

Table 2. Questionnaire Sections About Patients' Recent Experience With AP and Telemonitoring.

During your participation in the clinical trials, would you say that the telemonitoring tool used by the medical team was . . .					
	Not at all	Slightly	Moderately	Quite a lot	Extremely
Useful (%)	0	0	12	35	53
Reassuring (%)	0	0	18	47	35
Essential (%)	0	0	24	47	29
Would you have participated in the clinical trial . . .					
	No	Maybe	Probably	Yes	
Without the presence of medical staff (%)	29	41	12	18	
Without this remote monitoring tool (%)	29	13	29	29	

Regarding the next phase of outpatient clinical trials, when AP systems will be tested at home, 88% of patients think that AP should go with a RM tool. This percentage remains the same if AP was to be commercialized; however, the final usage would be different. During clinical trials, patients would rather have a telemonitoring at all times (59%), whereas they would clearly prefer noncontinuous monitoring (first use, in case of difficulties) when AP is a commercial product (82%).

According to participants, telemonitoring applications should collect data about glucose and insulin delivery details (88%) and about device technical information (94%). Besides, 59% would agree to share GPS localization so that it could be helpful in case of important events such as severe hypoglycemia.

All patients (100%) claim for an access to the telemonitoring web application to view their data. They all agree that their diabetologist should also have a full access to their information, but are less comfortable with giving permission to a spouse or a relative (41% yes, 29% no, 29% no opinion).

Although patients don't want to receive a phone call during a moderate hypoglycemia, half of them would like to get help when hypoglycemic episodes are severe or repeated. Regarding hyperglycemia, 65% of respondents would like to get called when it is prolonged, but only 35% when it is recurrent. Finally, 88% would like to be supported by a phone call when they encounter a technical problem with a device that is not working.

When asking patients what kind of technology could help them to improve their blood glucose control, AP arrives on top of the list, with 94% positive answers from moderately to extremely. Continuous glucose monitoring devices and mobile applications are in the second position with both 88% positive answers, while RM tools appear in the fourth position with a score of 76%. Physicians' phone calls or SMS reminders in case of difficulties are considered less helpful, with 64% and 48% positive answers, respectively.

Discussion

Telemonitoring applied to diabetes and more specifically to AP appears as a beneficial option to most patients who answered our questionnaire. Most of them find it useful and think that it should be part of future AP systems. Some of them even think that it could help them to improve their blood glucose control by itself.

Safety is the leading perception related to RM. This feeling is emphasized by the fact that patient ask for a telemonitoring at all times during clinical trials. However, when moving from initial prototypes and early experiences to more achieved and robust commercialized systems, RM would be considered as needed only at certain times. This shows that telemonitoring is perceived as very useful during the development of AP devices since it could help patients to get confidence in AP systems and facilitate their learning process. This could be particularly true for patients who are rather defiant to new technologies. Hence, telemonitoring could be proposed as a "companion" during the first weeks of AP use, and later be triggered when patients encounter some difficulties.

As expected, patients ask for a full access to their data. They also allow their diabetologist to see their medical information. This indicates that our participants understand the concept of telemonitoring, as a way to provide a personal and special access to their physician.

However, our patients don't want to be disturbed when a simple issue occurs. They first expect to be helped when a device is not working, which means that a permanent technical support should be established. They also ask for medical support when their blood glucose appears as unstable with repeated or prolonged hyper/hypoglycemia. Telemonitoring applications could indeed detect technical failures and adverse metabolic events such as severe hypoglycemia, and alert the care team when necessary. In current practice, diabetologists are informed only of severe or repeated hypoglycemia and only after some weeks, when patients come for a regular visit. Telemonitoring would allow an immediate medical intervention and adaptation of insulin therapy.

Table 3. Questionnaire Sections About Patients' Views on Telemonitoring.

In your opinion, when artificial pancreas will be tested at home, should it go with a remote monitoring tool?					
No (%)	12				
At certain times (first use, in case of issues . . .) (%)	29				
Yes, at all times (%)	59				
And when it will be commercialized?					
No (%)	12				
At certain times (first use, in case of issues . . .) (%)	82				
Yes, at all times (%)	6				
What kind of information would you be willing to provide to a remote server?					
	Yes	No	No opinion		
Information about diabetes (blood glucose, insulin . . .) (%)	82	12	6		
Information about devices (battery level, sensor change, malfunctions) (%)	94	0	6		
Your localization by GPS (in case of severe hypo for instance) (%)	59	18	23		
In your opinion, who should be allowed to access this information and/or receive alerts?					
	Yes	No	No opinion		
You, as a patient (%)	100	0	0		
Your spouse or a relative (%)	42	29	29		
Your diabetologist (%)	100	0	0		
A dedicated technical team (%)	82	6	12		
Would you like to be contacted by phone?					
	Yes	No	No opinion		
During a hypoglycemia (%)	6	88	6		
During a severe hypoglycemia (%)	53	47	0		
During a prolonged hyperglycemia (%)	65	35	0		
When hypoglycemia are repeated (%)	53	41	6		
When hyperglycemia are repeated (%)	35	47	18		
When a device is not working (%)	88	6	6		
What could help you in improving your blood glucose control?					
	Not at all	Slightly	Moderately	Quite a lot	Extremely
A continuous glucose sensor (%)	0	12	0	35	53
An artificial pancreas (%)	0	6	12	17	65
A remote monitoring tool accessible by Internet (%)	24	0	35	24	17
Phone calls from my physician in case of difficulties (%)	12	24	35	12	17
A follow-up application installed in my smartphone (%)	6	6	24	29	35
Reminders/alerts by SMS in case of difficulties (%)	29	23	18	18	12

We are aware this study has several limitations. The first one is the small number of participants. This can be easily explained by the fact that AP outpatient studies have started only 2 years ago, as pilot trials only, with very few participants. Even if numerous patients have heard about AP concept, very few have effectively used an AP device, and even fewer have experience with a telemonitoring system.

A second limitation is patient selection, since patients who volunteered for AP trials are rather patients who are quite keen on technology. However, this selection of patients allows catching relevant and accurate patients' feedback on a specific technology. Besides, investigated patients held middle to high educational levels, which are known to be more interested in telemonitoring projects.[19] They indeed used computers and smartphone very regularly, and their answers are not representative from the whole population of patients with diabetes.

Finally, the number of questions is restricted, and the questionnaire has not been validated. Our objective was not to assess users' satisfaction but only to get an initial snapshot

of patients' perceptions of the concept of telemonitoring. Our work certainly needs to be continued and repeated with more subjects to enhance our understanding of the role that telemonitoring could play in future AP systems.

Conclusions

This preliminary work supports telemonitoring as a component of AP developments since it appears as expected by the patients during upcoming home trials but also when AP systems will be commercialized. Larger studies will be performed to investigate its usefulness in wider populations and later both its specific efficacy on glucose control and economic effectiveness.

Abbreviations

AP, artificial pancreas; DiAs, Diabetes Assistant; GPS, Global Positioning System; RM, remote monitoring; SMS, short message service.

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