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Measuring Blood Glucose Levels

Testing of a multisensory concept

Attempts to measure blood glucose levels non-invasively with a sensor have not been very successful up to now. A company based in Zurich is now working on a design with several complementary sensors.

Spe. For many diabetics, pricking their fingers is just a part of everyday life. Several times a day, they must take a small blood sample to check their blood glucose level. This is unpleasant and tedious over the long run. Furthermore, in patients with strongly fluctuating blood glucose levels, there is the danger of not recognizing sudden episodes of high or low blood glucose. So for several years, researchers have been trying to replace the current practice of blood glucose measurement with a continuous measuring process. Needle sensors are already established in practice. They are inserted into the subcutaneous fatty tissue of the belly or upper arm and must be replaced after three to five days. Other researchers, however, want to go a step further and measure blood glucose levels with a sensor that does not injure the skin. Although much development work has gone into such non-invasive monitoring devices in recent years, none has met expectations. Now, Solianis Monitoring, a company headquartered in Zurich, has recently developed a modified design based on several complementary sensors. From the start, this development has involved experiments at the Clinical Research Centre at the University Hospital of Zurich.

Electromagnetic radiation as a probe

In order to probe blood glucose levels through the skin, researchers have examined very different forms of electromagnetic radiation. For example, attempts were made to measure the glucose concentration with infrared light, which penetrates the skin, scatters, and is then detected with a sensor. Theoretically, the glucose should be detected by characteristic absorption lines in the scattered light. In practice, however, the fact that water has an absorption spectrum in the infrared wavelength range similar to that of glucose is an interfering factor. Since tissue contains a lot of water, the glucose signal can only be calculated by using an elaborate mathematical process. Furthermore, miniaturizing the optical measuring system to the extent that it can be worn on the body has not yet been possible.

The researchers of Soliaris Monitoring are therefore making use of another effect, i.e. the fact that blood glucose levels affect not only the optical, but also the electrical properties of the skin. Already a few years ago, Pendragon Medical, a Zurich based company, attempted to measure this effect with a radio wave-based sensor worn on the wrist like a watch. The clinical tests were promising. Shortly before its market introduction, however, it was shown that the system only functioned if the patient was at rest. The market introduction of the product had to be called off, and the company filed bankruptcy.

Adversity makes you smarter

Today, some of the former Pendragon Medical staff are working for Soliaris Monitoring. One of them is Andreas Caduff. The failure convinced him, he says, that only an approach using several sensors can lead to success. In the meantime, the researchers have identified the most important factors by which the signal measured at rest is disturbed during activity. In addition to perspiration on the skin, skin moisture and changes in skin thickness, blood circulation also fluctuates. Caduff and his colleagues are now working towards the goal of detecting these disrupting factors with additional sensors in order to correct the disrupted signal.

In addition to a perspiration sensor like those used in lie detectors, the researchers have integrated several sensors operating in the megahertz and gigahertz range with different geometries on the same chip. Since depending on the wavelength, the electrical field of these waves penetrates the skin at different depths, the sensors react differently to changes in glucose content. In principle, this should allow the detection and elimination of disruptions occurring above the layers of skin supplied with blood. An optical sensor also detects changes in the circulation.

As the first experiments under controlled conditions have shown, this multi-sensor platform can actually track artificially produced changes in glucose content. Even during moderate patient movement, the statistical reliability of the measuring process is only insignificantly reduced. At the moment, Caduff and his colleagues are improving the methods of data recording and continuing to develop algorithms for data evaluation that take individual parameters such as sex, age and type of diabetes into consideration. This is being done on the basis of tests conducted under everyday conditions. A test model of the device that is fixed to the upper arm with a band has been used. Clinical tests with a prototype are to begin next year.

Mario Stark, the CEO of Solianis Monitoring, does not want to raise expectations too high. Stark emphasises the fact that they won't be able to totally eliminate the finger pricks. Blood glucose levels will have to be checked in the conventional manner, again and again, to calibrate the device. And even if the device gives an alarm, a blood sample will have to be taken in order to be sure before taking countermeasures. Thus, the sensor-based approach is not an alternative to the customary method of measuring blood glucose, but rather a complementary method. Stark believes the great advantage is that the measuring device is intended to indicate both the current blood glucose value as well as trends. This could especially help those patients who have erratically fluctuating blood glucose levels to better deal with their disease.

Training patients

For Peter Diem, the director of the University Policlinic for Endocrinology, Diabetology and Clinical Nutrition at the Inselspital in Bern, the advantages of a continuous and non-invasive measuring device are obvious as well. Diem warns however against excessive expectations. A lot of investors' money has been wasted in this area in recent years, since none of the non-invasive sensor systems has yet achieved the necessary precision and reliability.

Whether the multi-sensor design will deliver better results under everyday conditions remains to be seen. And Diem sees yet another problem. The experience with the already established needle sensors has shown that not every patient is able to draw the correct conclusions from the information provided by the device. Some patients are unsure of whether they can trust the measured values. Others ignore the advice to re-measure their blood glucose value in the conventional manner before taking action. According to Diem, developing a new measuring device is not enough. Patients and their attending physicians will also have to learn how to handle the new system correctly.