Non-invasive blood glucose measurement

The first attempt to determine the level of glycemia by a non-invasive method is a urine analysis. However, this is only an indicative method, and very precise values are needed, especially for patients with DM1. Nevertheless, even today, this method of analysis can help when diabetes mellitus or impaired glucose tolerance is suspected.

The aim of non-invasive blood glucose measurement is ideally CGM, whereby the patient himself would be informed of his current glucose levels without the need for capillary or venous blood sampling . One possibility is detection from the interstitial fluid, since the level of glucose in the blood correlates with the level of glucose in the interstitial fluid. It appears in the interstitial fluid only a few minutes later. Efforts towards non-invasive blood glucose monitoring are currently huge. However, the methods are still not reliable enough and often have a large deviation.

Split methods

1. **Optical**: NIR Spectroscopy and Raman Spectroscopy.
2. **Transdermal**: Transport of glucose through the skin (ultrasound, electrophoresis).

Near IR Spectroscopy

The spectrum for measurement is infrared radiation, which has a wavelength in the range of 1,000–10,000 nm. Analysis of this region of the spectrum yields important information (including the type of atoms in the molecules):

- **method** (NIR) **is in the 800-2500 nm range,**
- intermediate region **(MIR)** 2500–5000 nm,
- far range **(FIR)** 5000–10000 nm.

However, as the wavelength increases, the energy decreases. In other words, radiation with a longer wavelength (MIR and FIR) does not reach deep enough into the skin and is therefore unsuitable for analysis.

The NIR spectrometer consists of a radiation source, which is a heated substance (e.g. a Nernst rod). A monochromator is usually placed behind the light source. On it, the appropriate wavelength for detection is selected. The radiation passes through the sample and hits the respective detectors. It is true that the vibrational bands of glucose are located in the range of 1530–1850 nm in the NIR. At the wavelength of 1536 nm there is a band of the –OH and –CH group, therefore this band is the most suitable. However, the disadvantage is that the measurement is not completely accurate.

One of the possible NIR methods is *pulse glucometry*, which is based on the measurement of radiation transmittance in the spectrum ranging from 900 nm to 1700 nm. We only measure the spectrum of pulsating blood and the amount of glucose in it.

Another option is to *measure attenuated total reflectance*. An optical prism is used for this measurement. It has reflective surfaces on the inner walls, and in them the reflected beam from the measured sample is multiplied. This is sent to the sensing device and subsequently analyzed.

Diffuse reflectance is another option for measuring glucose . This involves capturing the reflected part of the radiation using a bifurcated optical fiber.

Raman spectroscopy

This method is based on the use of scattering of monochromatic light when interacting with matter. Each atom or molecule has its own specific properties when exposed to radiation. It can absorb the radiation (absorption) or emit energy in the form of radiation (emission) or both (fluorescence). Each chemical substance has specific properties for the absorbed or emitted spectrum of radiation. It is true that the given spectrum is not continuous and it is possible to detect it, from which information can be obtained about the given atoms and molecules. No two chemically different substances have the same absorption or emission spectrum.

In this case, it is the fact that glucose as a molecular structure after interaction with radiation emits specific vibrational bands that can be detected - well and selectively. Here, the light beam excites the electron , which releases a photon after returning . This scattered light has a different wavelength than the one incident on it. This is possible due to the resulting vibrations of the glucose molecules.

Furthermore, it could be said that Raman spectroscopy is actually a complementary method to infrared spectroscopy, but it is more selective. This technology can be used to measure the concentration of glucose in the aqueous humor of the eye. However, the disadvantage is that a long acquisition time would be required to obtain a quality signal with a minimum of noise.

Transdermal

The main principle is electroosmosis and the movement of ions through the skin in the presence of an electric field and subsequent measurement. See GlucoWatch Biographer.

Non-invasive glucometers

GlucoWatch Biographer

The watch was produced by the Cygnus company from 2002 for 4 years. After that, the production was stopped because the production costs were too high and there were problems with the short life of the device. This device clipped on like clockwork. Its other big drawback was that it needed three hours to warm up. Subsequently, it could be in operation for up to 12 hours, during which time the device measured blood glucose several times an hour. The information was then saved, but there was also an option to set an audio alarm to warn of hypoglycemia .

The main principle of the watch's function was electroosmosis and the movement of ions in the presence of an electric field. Human skin is physiologically negatively charged, which enabled the function of the watch. A very low electrical current in the watch drew the glucose through the skin to the surface, where the 2 discs that were part of the automatic sensor collected the glucose and sent it to an electrode that measured the blood glucose. The value was saved and displayed when the button was pressed.

The disadvantage of this measurement was the dependence of sweat and interstitial fluids on the condition of the patient's body. For example, the patient could influence the measurement value just by increasing the intake of liquids in food. Applying the watch involved only washing the wrist with alcohol, or shaving hair due to sufficient contacts. Unfortunately, patients often complained of reddened skin and the formation of blisters. It was recommended to keep the skin area clean and dry, or use skin creams. If the irritation lasted longer than a week, a consultation with a doctor was recommended.

Google Contact Lens

This smart lens project began in January 2014 in collaboration between **Google** and the pharmaceutical company **Novartis**. The complete device consists of three parts:

- the contact lens itself with a microchip and antenna;
- reading device or reader;
- a tool with a display for displaying data.

Contact lenses should be made of the same material as regular lenses, and the user should not feel any difference when wearing them compared to regular lenses. Google says that the power of the improved lens will be obtained from the reader. This system will include NFC **(Near Field Communication) technology**, for that reason there will be no energy requirements from the lenses. In this direction, maximum miniaturization of the technology is planned, for example the antenna in the lens will be thinner than a human hair. Placing the reader in glasses, clothing (scarf, hat) or jewelry (earrings) is being considered. The display could be a mobile phone with a smart application, a laptop, or Google Glass. However, the correlation between glycemia and glucose concentration in tears, i.e. accuracy and reliability, is problematic. Not to mention the cost of production. Google does not currently provide information about the project.

GlukoTrack

This is a non-invasive glucometer from the Israeli company of the same name. This device combines data from three sensors

1. **Ultrasonic** - the physical properties of the tissue will change depending on the concentration of glucose (speed of sound propagation and compressibility).
2. **Electromagnetic** – measurement of change in impedance (resistance).
3. **Thermal** – as a result of the change in perfusion, the transfer of heat in the tissues changes.

It is intended for patients with DM2 and patients with prediabetes.

- This is just a monitoring device.
- The device is not used for the actual diagnosis and initiation of possible treatment.
- It is intended for patients aged 18 and over and is very easy to use.

It consists of a so-called main unit and a clip-on device on the earlobe. The analysis takes place within 30 seconds and the user sees the glycemia on the display. The main unit is about the size of a larger mobile phone. The advantage is that the device can be used by up to three users at the same time and the battery in the main unit can be recharged. Data can be downloaded via USB or then analyze.

Links

Related Articles

- Diabetes mellitus
- Ultrasound
- Diabetes mellitus 1. type (endocrinology)
- Electrophoresis
- Diabetes mellitus 2. type (endocrinology)

- Spectrophotometer
- Self-monitoring glycemia

Source

- VÍTOVÁ, Hana. *Neinvazivní měření glukózy v krvi* [online]. Brno, 2012, Available from <https://www.vutbr.cz/_base/zav_prace_soubor_verejne.php?file_id=51236>.

- MUŽÍK, Jan. *Zahraniční projekty, neinvazivní senzory, dual hormon, léčba diabetu, úvod do Wikiskript* [lecture for subject Pokročilé technologie v diabetologii, specialization Všeobecné lékařství, 1. lékařská fakulta Univerzita Karlova]. Praha. 2.10.2016. Avaliable from <http://www.albertov.cz/wp-content/uploads/2018/03/zahraniční-projekty-neinvazivní.pdf>.

- 2. Jan Mužík, Pokročilé technologie v diabetologii, Zimní semestr 2016/17 http://www.albertov.cz/wp-content/uploads/2018/03/Zahraniční-projekty-neinvazivní.pdf

- 3. Svět androida, Co je NFC a k čemu je dobré ho použít?, 10.5.2016, https://www.svetandroida.cz/co-je-nfc-k-cemu-je-dobre-ho-pouzit/

- 4. 100+1 Zahraniční zajímavosti, Jan Miklin, 18. 1. 2014, Chytré kontaktní čočky od Google: V boji proti cukrovce, https://www.stoplusjednicka.cz/chytre-kontaktni-cocky-od-google-v-boji-proti-cukrovce

- 5. Václav Roman, 21. století, Chytré kontaktní čočky dokáží změřit hladinu cukru, https://21stoleti.cz/2015/03/11/chytre-kontaktni-cocky-dokazi-zmerit-hladinu-cukru/

- 6. PR servis České tiskové kanceláře, http://www.protext.cz/zprava.php?id=25089

- 7. 20451 Seneca Meadows Parkway, Germantown, MD 20876-7005, https://www.eversensediabetes.com/products/,

- 8. K. Peterson, Invazivní a neinvazivní metody kontinuálního monitorování koncentrace glukózy, http://www.bulletinfons.cz/22009/labo2.pdf

- 9. GlucoTrack, Non-invasively measure glucose levels in the body,Location Address: 19 Ha’Yahalomim St., Ashdod, ISRAEL http://www.integrity-app.com/the-glucotrack/

- 10. Od autorů: Rybka Jaroslav,a kolektiv, Diabetologie pro sestry, nakladatelstství GRADA, strana 92
- 11. DiaTribe, Making Sense of Diabetes, Google Secures Patent for Glucose-Sensing Contact Lens, 4/16/15, https://diatribe.org/google-secures-patent-glucose-sensing-contact-lens

- 12. GlucoWatch G2 Biographer, https://www.accessdata.fda.gov/cdrh_docs/pdf/P990026S008c.pdf

- 13. Wikipedie, otevřená encyklopedie, Ramanova spektroskopie, https://cs.wikipedia.org/wiki/Ramanova_spektroskopie