Technology, Study Results and Device Presentation of the truly non-invasive continuous Glucose Monitor PENDRA

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1) Glucose Monitoring
2) Technology
3) Device
4) The Hypo-Warning
5) Clinical Trials
Glucose Monitoring – A Major Challenge

Spot Measurements vs. Continuous Monitoring

Glucose [mg/dl]

Hyperglycaemia region

Hypoglycaemia region

Date / Time

Fingerprick reading

Continuous reading
Present Solutions for Glucose Testing

Traditional finger prick measurements or alternate site testing (AST)
- invasive
- non-continuous
- painful

Continuous monitoring for clinical use
- invasive
- using interstitial fluid (ISF)
- change of measurement site every few days
- no realtime readings

Continuous monitoring for home use
- minimally invasive
- using ISF
- no realtime readings
- limited number of readings
- skin irritations
Glucose Monitoring

- Radiation (non-invasive)
- Fluid extraction
  - Fluid extraction from skin
  - Interstitial fluid harvesting
- FIR Spectroscopy
  - Optical rotation of polarized light
- Ultrasonic +NIR Spectroscopy
- Impedance Spectroscopy is different

Measure Interaction → Calculate glucose concentration
Impedance Spectroscopy

Measuring permittivity and conductivity of interfacial polarisation processes in the $\beta$-Dispersion

Impact of glucose on electrolytes

\[
\varepsilon^*(\omega) = \varepsilon' - j\left(\varepsilon'' + \frac{\sigma_0}{\varepsilon_0 \omega}\right) = \varepsilon' - j\frac{\sigma'}{\omega \varepsilon_0} = \frac{\sigma^*(\omega)}{j \omega \varepsilon_0}
\]

Change of apparent dipole moment due to accumulation of ions on membrane (interfacial polarisation).

Am J Med 1999 Apr;106(4):399-403
Glucose vs Na in patients with Diabetes

n=15
Cell reaction on D/L-glucose

One-cell dielectric spectra

D-Glucose concentration dependance

L-Glucose concentration dependance

Sensor coupled to skin

Resonant circuit to measure changes in Z

Sensor coupled to skin

Resonant circuit to measure changes in Z

\[ |Z| \]

\[ f_{\text{min}} \]

\[ |Z|_{\text{min}} \]
PENDRA® - Sensor

Sensor plate

Arm
Calibration

\[ glu = \text{baseline} + \alpha_1 Z + \alpha_2 T_1 + \alpha_3 T_2 + \alpha_4 F + \text{additional terms} \]

at least 5 calibration points needed to define all coefficients \(\alpha_1\) to \(\alpha_4\)
NI-CGMD readings vs BGM

Day 1-3
Day 4-6
Day 7-9
PENDRA®

CE certified as medical device class type II b
PENDRA®

The device is designed

• as an adjunctive device to supplement blood glucose measuring

• to help to detect trends and patterns in glucose levels

The device will help physicians to simplify the control of patients’ therapy...

...and the patients will benefit from easier self-control, which results in an improvement of their quality of life
Approximation of Future Glucose Excursion
PENDRA® is Pessimistic

Information about glucose slope and its excursion

Limiting maximal glucose excursion to physiological range allows a worst case scenario prediction

Hypo alarm is triggered if glucose level will be under a certain limit after a defined time
Alarms are Triggered in Following Situations

I) Parameter extraction

Risk of getting into a hypoglycaemic state in near future (within next 20 min)

Glucose value is at or lower as the given threshold for hypoglycaemia

The patient is more than a certain period (e.g. 30 min.) in a hyperglycaemic condition

Rapid in- or decrease of blood glucose

II) First glucose calculation

III) Corrections and alarms
Pendragons’ Solution for Continuous Non-invasive Monitoring of Glucose (1)

- Truly non-invasive continuous realtime measurements
- Measurement frequency of 1 per minute – day and night
- Adjustable alert for upcoming hypoglycaemic conditions and for hyperglycaemic situations
- Trend indicator for changes of glucose
- Physician software for patient data management
- Patient software to visualize glucose excursions
- Storage capacity of 1 month
Pendragons’ Solution for Continuous Non-invasive Monitoring of Glucose (2)

- No blood sample or interstitial fluid needed
- No need of expensive disposables
- Offers physicians and patients the possibility of tighter control of glucose
- Helps to simplify the therapy management (acute and long term)
- Reduction of diabetes complications by continuous monitoring and management of hypo- and hyperglycaemic conditions
Clinical Trials

Some impressions
1. Clinical Experimental Hyper/Hypo Study

Glucose-clamp study

15 patients with diabetes type 1
  • Age 27 ± 5.7
  • Body mass index 23.1 ± 2.3 kg/m²
  • HbA₁c 6.9 ± 0.8%

BG kept constant at three different target levels (45, 100, 200 mg/dl) for at least 30 min at each level.

Venous BG was measured by a standard laboratory system

Haematology parameters were measured by BGA.

The raw glucose sensor signals recorded (frequency, impedance) were corrected for temperature and calibrated with reference values from each BG level.
Glucose vs Sodium in Patients with Diabetes

![Graph showing glucose and sodium levels over time.]

n=15
Clarke Error Grid Analysis

Corresponding Clarke Error Grid analysis:
81% in zone A
15% in zone B
4% in zone D

Correlation coefficient: 0.932

SEP 19.5 mg/dl.

2. Results of a clinical experimental trial

Comparison BGM vs. PENDRA®

15 Patients with diabetes

Clamp-Study by means of a Biostator®

Glucose-profile:

Results:
A 81%, B 18%, D 1%, correlation coefficient: 0.958
3. Results of an Outpatient Trial
a) Retrospective Analysis of Data

Comparison BGM vs. PENDRA®
15 Patients with diabetes
2 days of inhouse training
7 days of home use, 24h/d
7 – 10 BG readings per day

Results:
A 83%, B 15%, D 2%,
correlation coefficient: 0.923
b) Real Time Values

Comparison BGM vs. PENDRA®
15 Patients with diabetes
2 days of inhouse training
7 days of home use, 24h/d
7 – 10 BG readings per day

Results:
A 56%, B 37%, C,D,E 7%,
correlation coefficient: 0.640
c) Real-Time Tracking of Blood Glucose Profiles with PENDRA
PENDRA® helps patients in critical situations

- During night
- Living alone
- During work (stress related hypo’s)
- During car driving

PENDRA® Improves Quality of Life