Glucose biosensors for Diabetes Mellitus management

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INTRODUCTION

What is Diabetes Mellitus? [1]
- It may be an auto-immune disorder where the immune system destroys the Beta-cells of pancreas which causes scarcity in production of insulin (Type 1).
- It may occur when the body is resistant to insulin (Type 2).
- In some rare cases, there is increased blood glucose level during pregnancy (Gestational Diabetes).

Some common symptoms [2]:
- Increased hunger
- Increased thirst
- Weight loss
- Frequent urination
- Blurry vision
- Extreme fatigue

Blood Sugar Classification

<table>
<thead>
<tr>
<th>Blood Sugar Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>70-100 mg/dL</td>
</tr>
<tr>
<td>Prediabetes</td>
<td>101-125 mg/dL</td>
</tr>
<tr>
<td>Diabetes</td>
<td>141-200 mg/dL</td>
</tr>
</tbody>
</table>

Fasting Blood Sugar levels

<table>
<thead>
<tr>
<th>Blood Sugar Level</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Normal</td>
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</tbody>
</table>

Past Meal Blood Sugar levels

<table>
<thead>
<tr>
<th>Blood Sugar Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>200 mg/dL &amp; above</td>
</tr>
<tr>
<td>Prediabetes</td>
<td>200 mg/dL &amp; above</td>
</tr>
<tr>
<td>Diabetes</td>
<td>200 mg/dL &amp; above</td>
</tr>
</tbody>
</table>

Some complications [2]:
- Cardiac arrest
- Neuropathy
- Dementia
- Foot infections
- Skin infections
- Depression

<table>
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<tr>
<th>Complication</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac arrest</td>
<td>Causes heart failure</td>
</tr>
<tr>
<td>Neuropathy</td>
<td>Causes nerve damage</td>
</tr>
<tr>
<td>Dementia</td>
<td>Causes memory loss</td>
</tr>
<tr>
<td>Foot infections</td>
<td>Causes foot problems</td>
</tr>
<tr>
<td>Skin infections</td>
<td>Causes skin problems</td>
</tr>
<tr>
<td>Depression</td>
<td>Causes mood changes</td>
</tr>
</tbody>
</table>

Onset of symptoms:
- Type 1 diabetes: Usually occurs before the age of 30
- Type 2 diabetes: Usually occurs after the age of 40
- Gestational diabetes: Usually occurs during pregnancy

Diagnosis:
- Fasting blood sugar test: Determines blood sugar level without food for at least 8 hours.
- Oral glucose tolerance test: Determines how the body responds to glucose.

DIABETES MANAGEMENT

- lifestyle changes, such as healthy eating and physical activity
- medications, such as insulin or oral diabetes medications
- monitoring blood sugar levels through home testing or continuous glucose monitoring

ADVANTAGES OF GLUCOSE BIOSENSORS OVER LABORATORY TESTS [5]
- Routine analysis of blood glucose level is possible.
- Easy and time saving method of analysis.
- Patient does not have to rely on the laboratory tests (HBA1c Test & FBS test).
- Continuous monitoring of blood glucose level is possible.
- Wireless monitoring and easy recording of the blood glucose level.
- Initial investment is higher but daily cost is lower.
- Easier management of diabetes mellitus in elderly.
- Home-based self-assessment is possible.

COMPONENTS OF GLUCOSE BIOSENSORS [4][5]
- Biological recognition element
- Transducer
- Signal processing system
- Display/reader

TYPES OF GLUCOSE BIOSENSORS [4]
- 1st Generation: They were based on the use of natural oxygen substrate and on the detection of hydrogen peroxide produced. The main problem was the loss of enzyme activity due to the rapid degradation of the enzyme.
- 2nd Generation: Oxygen was replaced by non-physiological electron acceptors. A reduced mediator was fed into the device instead of hydrogen peroxide at lower operation potential. This can be further increased.
- 3rd Generation: The device was based on the use of low-oxygen substrate and on the detection of oxygen produced. They were based on the use of natural oxygen substrate and on the detection of hydrogen peroxide produced.

INNOVATIONS IN GLUCOSE BIOSENSORS

- Non-invasive glucose monitoring system [8]: They are of two types: subcutaneous glucose monitoring and continuous glucose monitoring. Subcutaneously implantable needle type electrodes measure glucose concentration in interstitial fluid. Risk of contamination and infection.
- Smart Pens [10]: The biosensor unit is a small needle and a pen-like device. This allows for convenient and easy insertion into the finger or other body part.

CONCLUSION

- Challenges related to Glucose Biosensors [6]
- Harsh conditions in which they are exposed. Some biosensors cannot be used in harsh conditions due to their sensitivity to temperature, pH, and other environmental factors.
- Degradation of enzymes, which can affect the accuracy of glucose measurements.
- Potential for infection and contamination, which can lead to false readings and inaccurate results.

REFERENCES