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How Will Magnetic Nano-Particle Technology Transform Diabetes Treatment?

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Abstract- Diabetes is a present and future global challenge that has attracted the attention of health experts. Diabetes falls under metabolic diseases caused by dysfunctional insulin secretion. The prevalence of this disease in three heredity, adulthood and pregnancy types has led to focus on how to treat and improve therapeutic procedures. Nano-technology, and more importantly, magnetic nano-particle technology plays a major role in improving treatment processes. So far, and in today's world, the most widely used method, as prescribed by physicians and used by patients, has been insulin injection, which has both advantages and disadvantages. Daily injection of this hormone may cause increased risk of developing different types of infections as a result of successive injections. Insulin delivery can be performed by types of nano-particles, along with polysaccharides, which may take both oral and inhalation forms.

Using nano-devices to measure blood sugar is evidence to demonstrate the positive effects of nanoscience on diabetes. It is much convenient and cost-effective to manufacture electrochemical nano-sensors to accurately measure insulin in the blood of diabetic patients than previous measurement methods.

There are also reports over the effects of magnetic fields on blood sugar homeostasis, though no general consensus is yet to reject or accept these reports. However, animal experimentations may help reveal how magnetic fields could reduce blood sugar, as exposing diabetic mice to a combination of electrical and fixed (static) magnetic fields for several hours a day could return blood sugar and insulin resistance to a normal state. Based on this unexpected discovery, it is possible to use electromagnetic fields to control blood sugar and manage Type 2 Diabetes. This impressive discovery may have major outcomes for diabetes care; especially for the patients who struggle from current treatment regimens.

Keywords- diabetes, insulin, nanoparticles, nanodevice, nano-sensor, magnetic field

Introduction

There are debates about making insulin capsules and replacing injection methods with oral consumption, and diabetic patients may soon get rid of insulin injection [1]. However, there are limitations in this connection that should be focused on. In the past, much effort was made to replace the insulin injection method with taking a pill; however, these pills were crumpled in the gastric acid and used to release insulin prematurely.

In animal experimentations related to the effects of electromagnetic fields, some research was conducted on human liver cells, in addition to studies on mice. The research found that electromagnetic fields create the same anti-diabetic effects in humans. Hypotheses and theories can be raised based on studies done on the animals more similar to humans in terms of size and physiology. The ultimate goal is to conduct clinical tests on patients to translate this technology into a new class of treatment procedures.

This study aimed to examine the effects of nano-technology on treating diabetes, and it is projected that this technology will have major impacts in a near or far future. This study will be directly or indirectly based on a survey of hypotheses and methods used in this connection.

- **Document analysis**
- **Oral insulin**

Oral drug-delivery is the most common way to deliver drugs to the body because it is a non-invasive method for patients. When taken orally, insulin is degraded by stomach enzymes. Meanwhile, capsulated polymeric nano-particles can be used to protect insulin.

A sample oral insulin made in the laboratory and tested on mice was placed inside a nano-particle. In fact, insulin was placed in the shell of this nanoparticle. This nanoparticle was coated with alternate layers of insulin and chitosan. The number of layers surrounding nanoparticles were adjusted to determine appropriate dosage. The size of each of these nanoparticles was around 200 nm. Insulin was first placed in liposome, which was then coated with 11 alternate layers of insulin and chitosan; an approach that helped carry more insulin.

Tests of this kind were also conducted on larger animals. Scientists invented a 30 mm insulin capsule, which was so strong that could endure in the stomach environment. This capsule has, so far, been tested on pigs, passing through the digestive system (e.g., esophagus, stomach and liver) with no harms. The insulin in the capsule is released once it reaches the small intestine. The small intestine is the ideal point for drug absorption because the surface of this organ measures 250 m and has no pain receptors. The protective layer of this capsule is made of methacrylic acid-ethyl acrylate dissolved at a pH of 5.5, with the capsule being released in the form of a triangle with three arms, after being broken down. Each arm has several one-millimeter needles that sticks to the intestine's wall and directly transports the drug to the bloodstream, thus initiating the reduction of blood sugar.

- **Insulin delivery through inhalable nanoparticles**

Inhalation is another method to deliver insulin to diabetic patients, though causing a problem with the production-distribution process. According to this method, nanoparticle must be so small to prevent lung obstruction and so large to prevent [the drug] from coming out when exhaling. Research has also demonstrated two major limitations with the insulin inhalation methods compared to oral methods; first, nanoparticles can move from the place of inhalation to other textures and cause unwanted responses in them, which may cause a simple inflammation or vascular thrombosis; second, low permeability through mucous membrane and the rapid-cleansing mechanisms cause the non-sticky compounds to be removed from the place of absorption [2].

- **Effects of [magnetic] fields on blood sugar reduction among laboratory mice**

In a test, 28 young mice were randomly divided into four a, b, c and d groups. Group A was exposed to the magnetic field for 20 days; Group B was exposed to a fake field for 20 days; Group C spent 10 days in a magnetic field and was then removed, while Group D spent 10 days in the fake field and another ten 10 days out of it. The magnetic field produced an induction power of 500 Gauss (Gs), produced by two blades of a natural magnet. The fake field was also created by two edges of a black stone, physically resembling the magnets. In the tests, the mice were weighed on a daily basis and had their blood samples and blood sugar measured by the end of the 20^{th} day. The weighing of the four-group mice was the same. The blood sugar of Group C was significantly less than those of Groups B and D; however, the blood sugar of other groups was not statistically significant.

- **Using electromagnetic fields for remote treatment of the blood sugar of diabetic animals**

New studies demonstrate that electromagnetic fields change the oxidant and anti-oxidant balance in the liver and improve responses to insulin. This effect is created by small reaction molecules, which seem to serve as "magnetic antennas".

The animals suffering from a higher blood sugar and Type 2 Diabetes due to a genetic change experienced natural blood sugar when exposed to electromagnetic fields [3]. In addition to studies on mice, researchers treated human liver cells using the fields for 6 hours, suggesting that the fields created the same anti-diabetic effects in humans. Since there is no evidence of the post-laboratory side effects in sample mice, and that there is a similarity with human liver cells, it is expected to unveil a new class of non-invasive therapeutic methods with remote control of cells, which would help patients fight the disease.

- **Role of nanotechnology in diabetes diagnosis and treatment**

Nanostructures are the main elements of nanotechnology. In each domain, a category of nanoparticles is widely used in technology development. Nanoparticles and carbon nanotubes greatly contribute to the diagnosis and treatment of diabetes. Nanoparticles mainly play the role of drug nano-carriers. Carbon nanotubes are widely used in diabetes diagnosis and treatment due to their high potentials. One of the most interesting applications of nanotubes is their conversion into antibodies. For this, the surface of carbon nanotubes is coated by a piece of polymer, which is used as a protein trap to entrap the intended protein among diabetic patients.

This technology also provides alternative methods of blood tests, such as using saliva, tears and urine to measure blood sugar. Also, patient's exhalation can be used to measure his blood sugar. There are over 300 compounds in the patient's exhalation, some of which are the known markers of the disease. In this connection, producing gas-sensitive sensors is required to use these markers. One of the symptoms of developing diabetes is the reduction in acetone concentration in diabetic patients' exhalation. Meanwhile, semi-conducting metallic oxide nanocomposites of tin dioxide and carbon nanotubes are used to make respiratory sensors that must be absorbent to the target gas (acetone). When acetone is chemically absorbed on the surface of a sensitive semi-conducting material, more electrons are transported to the sensitive materials due to the acetone's reaction with oxygen ions, thus enhancing the concentration of electrons and the sensors' responses, as resistance decreases.

There are other respiratory sensors that are more accurate than tin dioxide sensors, though they are yet to be commercialized. Gas chromatography can be used to identify acetone in exhalation. Researchers have developed a nanoscale for diabetic patients, which can identify small amounts of acetone. According to recent research, a mix of semi-conducting ceramic nanoparticles, coated on the gold electrode surface, can be used as a respiratory sensor. Prior methods of measuring blood sugar required a drop of blood, which was obtained from scratching a finger to help measure the glucose levels. Because this method was painful, researcher began to seek new ways to measure blood sugar without the need for the patient's blood.

- **Results**

In general, it is noteworthy to pay attention to oral drugs with protein origins instead of injecting them. Tests of manufactured insulin nanoparticles have demonstrated that the new formulation can carry a sufficient amount of insulin for leaving a desirable therapeutic effect, while being so small that can be transported to the bloodstream through the intestines' walls. Advanced insulin oral nanoparticles go through a passage through which natural insulin enters the body from the liver. Insulin capsules made in the laboratory can be fully solved in a sample animal (pig) body for several hours and is capable of being tested on humans.

Because the blood sugar of laboratory mice does not change that much during their stay in magnetic fields, the blood sugar of the mice, having been removed from the fields after ten days, will be clearly less than that of the mice never been in the fields.

Since, the exposure of diabetic mice to electromagnetic fields could reduce their blood sugar for a relatively short period of time and turn to normal their body responses to insulin, an electromagnetic treatment process can be invented to be conducted during sleep and control diabetes across the day. Exposure to magnetic and electro-static fields, approximately almost 100 times the earth's electromagnetic field, can reverse insulin resistance during sleep within three days after treatment.

The efficacy of nanotechnology on diabetes can be divided into two parts: measuring blood sugar levels and treating diabetes. Currently, there is so much research on improving blood sugar measurement. Meanwhile, various nano-sensors are under examination to diagnose and determine diabetes. These sensors play major roles in diagnosing diabetes and even other diseases. Many kits have been made for diagnosing diabetes marker biomolecules; for example, a smart lens has been developed that can measure blood sugar from eye secretions and there is a biochip that measures glucose concentration, if some saliva is placed on it.

From a therapeutic point of view, polymer nanoparticles can be used as insulin nanocarriers. Test results on polymer nanoparticles indicate that insulin can be released slowly and with a relatively linear pattern from inside this nanocarrier after 4 hours at a neutral pH and temperature of 37°. However, around 20% of the drug is released at an acidic pH in the first two hours. Hence, nanoparticles remain stable at this pH and the insulin is not released in the gastric acidic environment, and it can thus reach the small and large intestines. Using nanoparticles, which serve as an artificial pancreas, is an interesting treatment idea. Another method to solve the pancreas problem is that nanoparticles are used to deliver drug to this gland, which is quite suitable for patients who suffer from type 1 diabetes [4].

Coating carbon nanotubes with DNA could help make an accurate sensor for measuring biomolecules in diabetic people. A sensitive electrode, used to identify diabetes, is a combination of enzymes and carbon nanotubes. This compound is not just limited to biomaterials; rather it can be combined with metallic oxides such as nickel oxide and oxide to produce a diabetes sensor.

- **Discussion and Conclusion**

Currently, the best method to transfer insulin to a diabetic person may be to inject it in the body, as suggested by many professionals who advise this injection method. Creating nanocarriers that can penetrate faulty cells without leaving any effects on healthy cells is a challenge that may change the way insulin is taken. In this connection, appropriate carrier systems for protein-peptide drugs, especially for their oral consumption, is a major topic among drug experts, and its significance arises from a major limitation with the stability of proteins and peptides in the body environment and their delivery to the target texture.

Oral insulin is preferred to injected insulin for patients because it prevents the risk of infection and causes less pain. However, the production of oral insulin still remains a serious challenge.

Effort to produce oral insulin has seen some progress because these products either have a safety risk or require repeated dosages due to limited drugs and the delivery of little insulin. On the one hand, positive results of various tests conducted on making insulin capsules and investigating its effects and side effects in sample animals are very promising. It is hoped that nanoparticles play major roles in treating diabetes and modern drug delivery methods.

Using nanoparticles that can deliver drugs or therapeutic stem cells to affected areas may be a great alternative to systematic treatments because using fewer drugs could yield better treatment responses and reduce drug side effects.

The above was a summary of scientific, empirical and laboratory findings. Concerning the diagnosis and treatment of diabetes, there are various solutions and methods that can help with the identification and treatment of diabetes. We know that it takes too long to produce and commercialize medical equipment and medicines and there is a long way to produce nano-technology products in relation to diabetes.

Magnetic fields are everywhere. Effort to understand the basic mechanism of biological effects of magnetic fields on animal blood sugar and insulin resistance reveals that animals sense the earth's electromagnetic fields and use them for orientation. These studies refer to a quantum biological phenomenon by which electromagnetic fields may react with special molecules. There are molecules in our body that are perceived to operate as magnetic antennas and facilitate biological responses to electromagnetic fields. These fields can be used to treat diabetes and some other diseases.

- **Suggestions for future studies**

New drugs are obtained following a better understanding of the cellular mechanisms of various diseases. Hence, understanding cellular effects and their structural developments, especially in diabetic people, greatly contributes to facilitating the diagnosis and treatment of this disease.

Modern drug delivery systems are required for employing the targeted use of drugs made based on nanoparticles. Nanotechnology and modern drug delivery systems have transformed various medical sciences, especially drug delivery systems. Despite a myriad of advantages, the employment and commercialization of these products require an accurate and comprehensive study from a toxicological perspective and investigating their effects on living cells in the short- and long-term. Studies on the functioning of these modern nano-systems and their relationship with drug structures can help users better understand the subject and understand the relationship between nanotechnology and the ideal methods of insulin consumption.

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