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Alzheimer's & Nanotechnology:
Uses and possible treatments

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Abstract

Alzheimer's is a severe and degenerative brain disease, which over a period of time causes the patient to lose limb function, social skills, memory and coherence. It often leaves patients frustrated and with their lives cut short. At this time there is no definite diagnostic approach and no effective cure to the Alzheimer's disease (AD). In this paper we shall be looking at the effects of Alzheimer's and how Nanotechnology is being used to create and develop treatment for this harrowing disease. Over the past two decades nanotechnology has progressed from a theoretical "robot" science to a real treatment, offering fantastic prospects for the future of medicine.

Introduction

For many years Alzheimer's has hung over the medical community, but with the introduction of Nanotechnology it is now possible to work in the brain at a microscopic level. Nanotechnology is the umbrella term that describes a quickly evolving field of technology based on manipulation of matter at a sub-micron scale which embraces objects, mechanisms, assemblies and various drug delivery systems on the scale between 1nanometer(nm) and 100 nm. With the growth in general nanotechnological knowledge, recent years have also seen growth in the research of nanopharmaceuticals which has the promise to provide advances in the diagnosis and treatment of disease.

Alzheimer's was discovered early in the 1900's but was not recognised as an actual condition for another half century. Even now it is a misunderstood condition with sufferers facing much prejudice, but in its early years after discovery it was considered to be a natural part of the ageing process.

It is a harrowing disease for the sufferer and their family, as both are aware of the progressive loss of cognitive ability, control of movement and ability to speak coherently. The reason that the disease is progressive is that as a nerve cell dies it is not replaced and so as more die the brain effectively shrinks. The loss of different abilities depends upon which part of the brain is affected for example damage to the occipital lobe may cause loss of vision to ensue, but it most commonly occurs in the hippocampus, hence the memory loss. The pathology of Alzheimer's disease is progressive one of nature; the minimal repair and regeneration capacity of the brain tissue make this process almost irreversible. This necessitates a relatively early diagnosis and prevention of the disease. The earlier we can stop the pathogenetic process the less the patient will remain symptomatic. Therefore the undertaking of precise diagnosis procedures for screening the population with a high risk of

Alzheimer's disease is the preferred current approach against the disease. However currently there is not any single diagnostic tool for precise screening or for early accurate detection and diagnosis.

At present it is one of the most expensive health disorders for both the patient's family and for the society. For example, Alzheimer's disease which affects 400,000 people in Great Britain, costs the U.K Government £20 billion per annum with family members who care for those with Alzheimer's saving them £6 billion a year. Also in the United States Alzheimer's disease is costing the country more than \$100 billion per year and it is currently predicted that this figure will increase to near \$500 billion per year by 2020. Part of this cost is the drug treatments that are available to patients. The most popular of these are Aricept, Exelon and Reminyl, all of which release a chemical "blocker" to prevent to spread of nerve cell death.

The importance of medical applications of nanotechnology is more evident in diseases related to the central nervous system. This is mainly due to the highly elaborate structural and functional properties of the central nervous system. Nanotechnology is promising a non-invasive access to this complex system that is not presently achievable by other approaches.

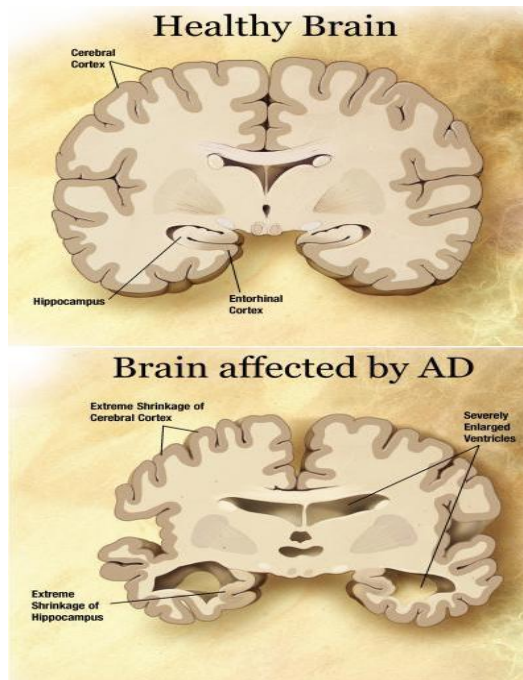


Figure 1- The damage caused to the brain by Alzheimer's

Discussion

Nanotechnology has opened many new doors in terms of medical treatment. The super small particles mean that procedures are non invasive and can not only prevent further damage but have the ability to repair damage already caused by Alzheimer's.

Generally the penetration of drugs into the brain is strictly limited. Large pharmaceuticals are unable to cross the Blood Brain Barrier with no exceptions. Only less than 2% of small molecules can cross the Blood Brain Barrier. All therapeutics aimed to a target in the brain must have a group of specific characteristics for crossing the Blood Brain Barrier these include having a small size, lipophilicity and compactness (which is measured from polar surface area). Nanotechnology can improve the efficiency of some potential therapeutic agents for central nervous system diseases including Alzheimer's disease by facilitating their delivery across the Blood Brain Barrier.

Gold nanoparticles are only nanometers or billionths of a meter wide and when used in conjunction with incredibly weak microwaves, have been found to dissolve problematic clumps of protein called beta amyloid plaque (Marcelo Kogan 2006). The amyloid builds up into thick layers, called plaque, outside nerve cells. These lumps of protein are thought to be one of the causes of Alzheimer's as scientists believe that amyloid is toxic to cells, causing them to die. Similarly Tau tangles have an effect on the nerve cells. Tau protein is produced by normal, healthy nerve cells in the brain; however in a patient with Alzheimer's an anomalous version is made. This version builds up and becomes entwined within the cell effectively smothering it.

Chad Mirkin, a researcher from nanosphere, also found that gold nanoparticles have their uses in terms of Alzheimer's treatment. He has helped to develop a detector, which is based on and utilises Gold nanoparticles to detect Alzheimer's, and hopefully in future to be used to treat it (Kevin Bulls 2006).

Bio-barcode assays and localized surface plasmon resonance nanosensors are two methods for the cerebral spinal fluid analysis for Alzheimer's disease biomarkers.

Cerebral spinal fluid has a higher degree of accuracy and can show brain tissue damages earlier than the known plasma biomarkers associated with Alzheimer's disease. However, the *in vitro* cerebral spinal fluid analysis requires the invasive procedure of lumbar puncture for obtaining a sample.

Nanotechnology has the potential to provide us with ultra sensitive *in vivo* detection methods (for instance with quantum dots, although their toxicity could make this approach problematic) of the Alzheimer's disease biomarkers in plasma. It is believed that the ultimate goal for very early detection of an underlying Alzheimer's disease pathology would be the development of a safe and implantable nanoscale biosensor for prolonged monitoring of Alzheimer's disease biomarkers in the cerebral spinal fluid.

Other scientists have also been successful in manipulating nanoparticles. It has been found that magnetised nanoparticles can be used to extract proteins from blood. The particles have been placed into a blood sample and they were found to 'stick' to the loose ends of DNA and proteins, which were then pulled out along with the particles. This has possible uses for Alzheimer's as it could be used to extract the Beta amyloid plaque which builds up around nerve cells in the brain, which in turn may prevent or halt the progression of Alzheimer's.

Conclusion

Alzheimer's disease is the primary common dementia syndrome worldwide, with an astronomical devastating burden on society. Solving the major problems of early diagnosis and effective cure for Alzheimer's disease requires interdisciplinary research efforts. Research on the basic pathogenetic mechanisms of the disease has provided a new insight for designing diagnostic and therapeutic methods. However, the need for further studies on the exact root causes of Alzheimer's disease is still palpable.

Nanotechnology has the potential to change millions of lives. The suffering that Alzheimer's causes can be eradicated and so to can the disease. Nanoparticles seemed a million miles away in the 1980's but in less than three decades they have become and are still becoming a real medical and scientific resource. Alzheimer's affects 5.3 million people in the United States alone, imagine if all of those could be

cured or at least have the progression of their disease halted, imagine the amount of money that could be saved by the Government.

It is not only the personal aspect of the disease that could have a major impact on the future, the high living costs in the more economically developed countries could be eased with the help of nanotechnology. The billions of pounds usually spent on medical care could be reinvested into the economy, improving the lives of others and allowing previous sufferers to lead longer and more fulfilling lives.

It is not just Alzheimer's that nanotechnology has the potential to treat, but also more lifelong problems such as genetic illnesses or Multiple Sclerosis. In future it may be possible to use nanotechnology to fix problems within the body e.g. mending bare nerves. With such a positive future there is no doubt that nanotechnology will change the face of medicine forever.

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