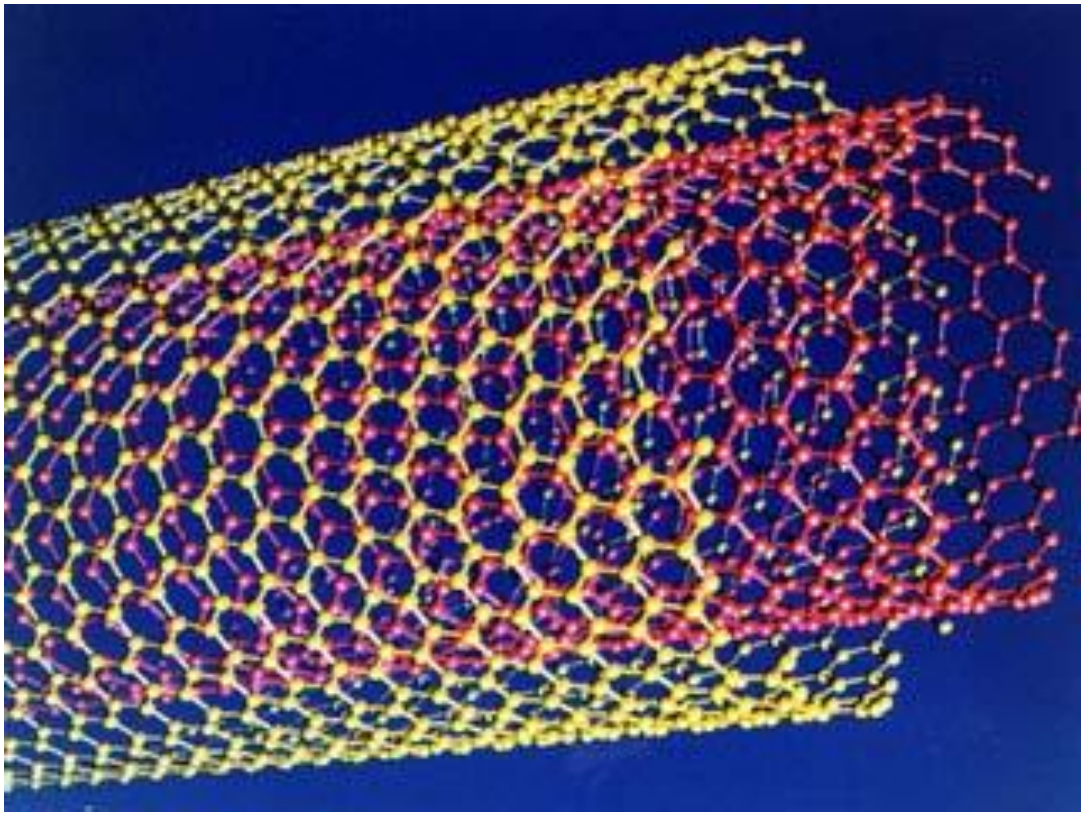
THE MEDICAL APPLICATION OF NANOTECHNOLOGY IN THERAPY, DIAGNOSTIC AND ANTI-MICROBIAL TECHNIQUES



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RESEARCH PAPER
BASED ON
PATHOLOGY LECTURES
AT MEDLINK 2010

Abstract

Nanotechnology is a very exciting possibility for medicine. It's a very new idea as it has only come into existence in the last century but it gives a chance for entirely new treatment methods and can solve many problems. The possibilities of Nanotechnology are almost endless, it can be used in therapy techniques, imaging and diagnostic techniques, anti-microbial techniques and even cell repair. In this paper we will be talking about how Nanotechnology has already advanced to aid in medical treatments and the possibilities that Nanotechnology could solve in the future. We will also be discussing whether the possible new treatments would be ethical and whether they are worth the large amounts of research. Overall we believe that the research would be worthwhile due to the large positive impact it could have on the treatment of cancer.

Introduction

History

The term Nanoparticle means an object which ranges in size form 1nm to 100nm. Nanoparticles have been used for many years; they were even used in medieval times to mix Nanoparticle pigments for stained glass. Technology has been advancing a lot of the last couple of decades; computers and circuits are getting much smaller and far more advanced, there is a higher understanding of how the body works and how different chemicals affect it and even the chemicals we use to treat problems with the body are getting far more complex. This is all due to the huge amount of research in all the different fields of technology and biochemistry. With all of the technology advancing and become more complex it was only a matter of time before there was the idea of using molecular sized robot to control and manufacture complex chemicals. Although the term "nanotechnology" was only first thought of in 1986 the idea had been brewing for a while longer.

Uses (Buckyballs and Nanotubes)

In 1996 three scientists (Kroto, Curl and Smalley) won the Nobel Prize for the discovery of a new allotrope of carbon which had 60 carbons arranged in a truncated icosahedron structure which they called the Buckminster Fullerene or "Buckyball" for short. These balls are about 1nm in diameter and are arranged in a football-like structure. This makes them very useful in medicine as they can be used in drug administration. A drug can be placed inside this cage like structure and so it can be delivered slowly making the drug released over time. It also makes the drug more efficient and safer. Another Carbon nanomolecule is the carbon nanotube. It is made up of hexagons of carbon atoms that form together like chicken wire; these nanotubes are so small that they can

enter the nucleus of a cell. So far they have only ever been used to ferry a peptide into a fibroblast cell but in the future they could maybe used to deliver vaccines or drugs. Although obviously it depends on the Nanotube as they can vary in things like diameter or length. Because the nanotubes and Buckyballs have very small holes for the drugs to escape through they have shown in clinical tests to have a very high biocompatibility and low toxicity even with a high dosage of the drug. This allows the drug to be delivered less frequently as more can fit inside the Buckyball and will be released over a long period of time.

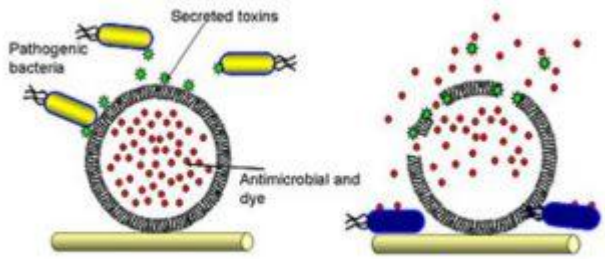
Uses (Quantum Dots)

There are Quantum Nanocrystals that are used in biological testing which are fluorescent. These fluorescent Nanocrystals can be delivered into cells and provide a stable fluorescence which can be tracked through generations and will not pass to neighbouring cells. It gets into a particular cell using a custom targeting peptide. This allows you to view the behaviour and functions of cells and how they work. These crystals can also produce different coloured fluorescence which means you can study many different types of cells at the same time and how they interact with each other. This can be extremely helpful with developing cures to disease as firstly scientist will be able to watch complex changes in diseases shown in different colours which will give them a greater insight into how diseases work and will allow huge advances in the pharmaceutical field. However if the right protein tracker is selected these Nanocrystals could be used in blood samples to show what disease the person has got or on a larger scale it could be administered to show whether someone has cancer or has risk of heart attack, the uses of these fluorescent particles could not only mean that it is easier to spot signs of cancer and so start treating it earlier, it could also give the surgeon an exact picture of which cells are infected and will make surgery much easier to have a successful removal of the cancer cells. These Quantum Dots open up a large opportunity in Nanotechnology, not only will they make huge advances in medicine but they also open up the ideas of things like fluorescent tattoos.

Uses (Anti-microbial Nanocapsules)

There has been a recent study to make a nanocapsule that can be used in the dressing that is put onto burn patients; it is a special type of capsule which will only release antibiotics when there is the presence of disease causing pathogens. When the toxins of the pathogen are detected the

capsule breaks down releasing the antibiotics and stopping the infection before it happens.



This is particularly important in burn patients (especially children) as this can lead to toxic shock syndrome which is potentially fatal. These capsules are extremely important in the anti-microbial cycle as they also change colour when the antibiotic is released allowing the healthcare professionals that an infection has occurred. These have an advantage over regular antibiotics as they are only released when the pathogen is there meaning that it reduces the risk of an evolution of an antibiotic-resistant super-bug such as MRSA.

Discussion

One of the main problems that occur in both males and females is cancer, it is estimated (by the Year 2002 Surveillance Research from the American Cancer Society) that in 2002, 555,500 Americans would die from cancer which averaged on 1,500 everyday. Cancer is such a huge problem because it is extremely hard to catch early and the later it is caught the harder it is to totally eradicate it. There are three main ways of treating cancer, Surgery, Radiotherapy and drugs. All three of which could in some way be improved by the use of nanotechnology.

Firstly chemotherapy, this attacks cancer cells by affecting the control centre that allows the cells to divide. However they also attack any cells which divide quickly such as hair cells. However this could be improved by nanotubes. The drug could be delivered by nanotubes to the exact place where the cancer is due to the targeting ability of nanotubes helping to focus the drugs much more efficiently. This can be made possible due to the high affinity of cancer cells for folic acid which is used within nanotubes to locate the tumours. The scale of gaps in the nanotubes mean that in normal blood vessels the drugs cannot escape through the walls of blood vessels, however in far more leaky blood vessels to tumour cells the drugs can escape directing a straight dose of drugs to the tumour tissue. As well as this the method of nanotubes in delivery means that smaller amounts could be released over a long period of time to eradicate the cancer cells. This method means causing less damage to other cells and will be far safer option for treating the cancer. Also without the problems such as hair loss which are associated with chemotherapy. Therefore the use of nanotubes would overall make the whole process far more efficient to the extent it could possibly serious reduce the ability of the cancerous cells to proliferate therefore stopping the cancer.

Another cure for cancer is surgery; this is where a biopsy will be taken from a certain tissue to see if it is cancerous. Then a surgeon will cut out the tumour and a bit of tissue around it known as the clear margin. This will be sent to a lab which will let them then know whether any other treatments are required. However this treatment isn't very safe because obviously as a surgeon is cutting into the tumour if a mistake is made it could quite easily severely harm the patient. There is also a risk that the cancer could return in later year to a neighbouring tissue. Nanotechnology could aid this with the use of Nanocrystals. These could be targeted for cancerous cells, this would reduce the time for the biopsy to occur as it would show very clearly which cells are cancerous, and it would always

help the surgeon to remove every bit of cancerous tissue without having to remove unnecessary tissue as all cancerous cells would be fluorescent.

The other main treatment is radiotherapy, this works by passing radioactive waves through the body which kills cancer cells; this does however cause damage to the healthy cells around the cancer. Many different waves are fired from different points to reduce the risk of damaging normal cells and so only the cancer cell get the full treatment although in some cases there have been permanent side effects and have caused serious damage. There are now Nanoparticles which could be attached to cancer cells, through the targeting ability and therefore only be present within the cancer cells. With this done, the nanoparticles can be activated by a few x-rays, which when activated then release electrons to the cancer cells which kills them but without causing damage to nearby cells. This allows cancer cells to be destroyed with a much lower concentration of x-rays and means there is less damage to surrounding cells, this could mean that radiotherapy could become much safer and there is a far lesser risk of short and long term side effects. As well as again being an answer to completely destroying cancer in an area as there would be very little chance of any cancer cells surviving as they are all targeted by the nanoparticles.

Finally nanotechnology in medicine also could be contributed to aid in a far less common treatment to cancer that could be very successful and this is thermotherapy. This treatment also relies on the targeting ability of nanoparticles to find and attach themselves onto the cancer cells in the body. Once this is achieved the nanoparticles would be able to be located through a technique known as time-resolved infrared imaging, helping to identify the exact position of the tumour in the body. As well as the possibility to discover metastatic tumours early, if the nanoparticles are located in areas away from the main tumour, which may be particularly helpful for treating lung cancer where the possibility for metastatic tumours is higher than normal. Once located the nanoparticles would be heated using laser irradiation and as they heat up kill the cancer cells they are attached to. A main use of this treatment, which is already offered today, is the treatment of prostate cancer using this laser treatment to kill the tumour without many of the intrusions other methods require. This means far fewer side effects such as impotency which all patients would want to avoid. This treatment, especially the use of the time resolved infrared imaging, could be utilised to treat many

other forms of cancer also, due to very few negative side effects and the efficient killing of all of the cancer cells.

However, despite all the positive advancements and potential for nanotechnology in medicine there are also some ethical issues brought in by this fast improving area of medicine. Firstly there are social implications to such new and advancing technologies such as nanotechnology. In this case for nanomedicine the issue is raised that these improvement of the new methods are being driven by a "technological push" rather than the need for making people better. This means overall that decisions are made and areas funded on what will bring the biggest wealth rather than the best treatment. To put this in context it is evident in the global view of health these high tech treatments are not what are really needed, but rather simply a greater supply of far simpler solutions that are perfectly adequate. It is here that the social implications have an effect as people may be suffering in other parts of the world due to a lack of effective treatments and drugs but all the while funding is instead being put into these technological advancements. So for medicine and health worldwide, whatever the advances, the improvement of nanotechnologies, as well as other similar high tech treatments, may be getting in the way of better global health merely for the financial gain of only a few.

Moreover the actual impact of nanotechnology on those who experience the treatments is not necessarily always positive. With the possibility that nanomedicine may in the future be able to give great detail about our bodies, from the cellular level that it works at, how will we be able to determine a healthy person when we have such a vast array of detail about their bodies. It is this that, when looked at from a patients point of view, could mean a check up for a bad headache may lead to discovery of a susceptibility to pancreatic cancer, which will simply cause worry and stress for the patient when little can be done to help.

Finally an extremely significant ethical issue arises due to the potential for nanotechnology as a method for improving the capabilities of humans. It is suggested that nanotechnology may not just be "making people better, but in fact making better people". This possibility, due to the potential for nano scale chips or sensors, brings on various issues including moral and equality questions. Such as is it right for parents to be able to engineer their children as well as if made available, who would have access to such technology. This is a well debated issue worldwide in

respects to making changes to the natural attributes of humans. Overall this is a large problem to overcome for nanomedicine as even as simply a method of treatment for health these possibilities and implications can cause a lot of mistrust. The resulting problem also due to the long term effect of such a use for nanotechnology as it is Germline therapy. This means that not just the patient will be affected, but the descendants of the individual also which begs the question whether it is fair for these future people, who may, if given the choice, not consent. This in the end is likely to hinder the advancements of the field and prevent it becoming a successful method for the eventual full treatment of cancer.

Conclusion

As discussed above the use of nanotechnology is growing greatly due to the huge number of breakthroughs and improvements this field as had. It has become extremely useful in various aspects of medicine, including surgery, drug delivery as well as especially in numerous therapies and in diagnostics. The usefulness of Nanotechnology in medicine however can still be improved as discussed above in the area of Cancer treatments.

As discussed, Nanotechnology brings the chance for many improvements to current cancer treatments, such as Chemotherapy as a drug delivery and targeting agent. In surgery aiding in the actual acts of surgery helping to highlight Cancerous areas and therefore reducing serious side effects. And finally helps to improve the method of radiotherapy through the decrease in risk of side effects and reduction of damage to other tissues, aiding in a quicker recovery. As well as this new methods could be made available through the use of lasers and heat in destroying cancer. This new possibility is another successful option for patients, especially where other treatments may not be so successful or safe. However there are also some problems and ethical issues brought up by these advancements and possibilities. This especially is true of any advance in human improvement, which is highly controversial and the base of many debates. Currently due to UN convention of Human Rights and Biomedicine it is forbidden and as a result any advancement will strike up much debate but this convention will stand in the way. Also highlighted were the issues of social and personal problems for Nanotechnology which together may possibly prevent improvements to the field.

The setbacks to the improvements of Nanotechnology for cancer treatment are mainly these various ethical issues that surround the idea. This mistrust of the new technology currently stands in the way of great medical and scientific breakthrough for Nanotechnology. However this setback, in the future, can possibly be overcome through clinical test results. This proof that the technology can be used effectively to combat cancer would guarantee large scale support, both socially and financially.

Another setback could be the potential for Nanoparticles used in the proposed treatment methods could be toxic to humans as shown by the toxic nature of other nanoparticles used commercially. In a commonly used nanomedicine particle the toxicity is due to the triggering of a form of cell death. However this may also be overcome as chemicals are being researched and some success gained in the use of an inhibitor of this cell death being added with nanoparticles which already seems to reduce this cell death and therefore the toxicity.

In conclusion overall the use of Nanotechnology in medicine holds a great chance for the improvement of many areas of medicine. But as discussed above also extremely useful in the advancements of cancer treatment which in the future has the possibility for great success.

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