

Nanomedicine and War

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PASS WITH MERIT

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The aspect of nanotechnology that we would like to explore through this paper is Nanomedicine in the field of war, incorporating both practical applications on the front, and aftercare of soldiers. We would like to explore this area of practical medicine because it is very much in the public eye and we feel that it is an area which would be of great benefit to developments in medicine at war. After exploring the many different uses and applications of Nanomedicine, we came to the conclusion that nanotechnology could have numerous uses and great value to the armed forces.

Nanotechnology is an area of science still very much in development; however once in proper use it will have great benefits to many scientific fields, especially medicine. This is because of the size of matter that is being manipulated, with three atoms measuring just one nanometer. By using these nanoparticles, medicine can become much more precise and immediate in diagnosis and treatment, as nanotechnology provides more specific cell targeting, a scaffolding for tissue repair and greater efficiency in surgery. For example chemotherapy need not infect the whole body, only cancerous cells if applied using nanotechnology. These are only a few of the many advantages that nanotechnology can bring to the medical profession.

In recent years, there have been many developments in nanotechnology and its uses. Due to technological advances, it is now possible to produce new molecules and robotics which operate on an atomic level, such as Buckminsterfullerene, a new allotrope of carbon, discovered in 1985 by Richard E. Smalley, whose work was published fully in 1996. These `Buckyballs` may have endless potential for significantly improving treatments and care of patients, as it is possible to contain drugs within them, therefore allowing patients to take medication orally without it being dissolved or broken down in the stomach, meaning it is no longer of use. Properties of the `Buckyball` also include being able to withstand extremely high speed collisions, and very high compression strength. This can be useful in high pressure areas of the body such as the heart, and in areas where collision with other larger molecules is likely.

Another significant area of work with carbon is in nanotubes, credited by the work of Sumio Iijima (1991). These are single layers of carbon atoms covalently bonded into a tube. The applications of these specifically include building lightweight but very strong structures for example, spacecraft, as NASA are currently researching. The nanotubes are also able to penetrate cell membranes and walls, due to their long, narrow, needle-like shape, presenting the possibility of injection of drugs and toxins into specific cells, including cancerous cells and bacteria. This could potentially stop fatal tumors and disease developing in the body.

Nanorobotics also presents many possibilities for new age medicine. The first steps in nanorobotics were made in 1989 by a group of IBM researching engineers, who manipulated atoms using a manual system. The creation `nanobots` has great advantages for surgery, as without making painful and infection-prone incisions, nanobots can be remotely controlled from outside of the body, as well as being able to target single cells with greater ease than previous surgical tools. Cosmetically, the patient receives few or no external scars from the surgery. Furthermore, these robots can be used to clear cholesterol build up in blood vessels, decreasing the number of coronary heart disease patients, decreasing the likelihood of heart attacks and strokes.

Severe burns also have the potential to benefit from nanotechnology due to ongoing research conducted by Dr Renate Förch at the Max-Planck-Institute for Polymer Research. The project is aiming to develop dressings which alert doctors when a burn is infected and help to eliminate the infection before it can become fatal. The dressing works as it is coated

in nanocapsules that contain a dye and antibiotics. When the capsules are attacked by toxins from the bacteria, the toxins break open the capsule and so the contents of the nanocapsule are released; the dye causes a colour change alerting doctors of the infection and the antibiotics kill the disease causing bacteria, as shown in figure 1. A particular advantage of this mechanism is that the antibiotics are only released when needed, reducing the risk of antibiotic resistant bacteria such as MRSA.

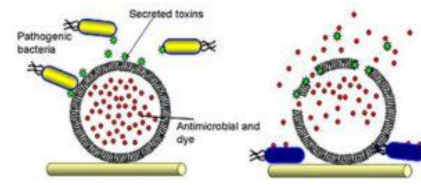


Figure 1

Nanotechnology has also spread to the most complex part of the body. Recent discoveries by Dr. Eberhard Fetz at Washington National Primate Research Center, Washington University, and supported by research performed by others such as Dr. David Colman, Montreal Neurological Institute and Hospital, have found that nerve damage caused during surgery on the brain and by foreign bodies can be repaired by injecting amino acids into the damaged area. Once these amino acids reach the environment of the severed connection, the chains bind to one another forming nanoscale fibres, which act like scaffolding holding the ends in place, preventing scar tissue from forming. From here the nerve connections can potentially repair and reconnect, although this is still being investigated. This is a major breakthrough in curing illnesses such as strokes, retina damage, and potentially spinal cord damage and traumatic brain injury.

A successful area of nanotechnology that is already in use today is within self cleaning glass. Coated with titanium dioxide, these particles fill in rough surfaces, creating a smoother surface with reduced friction. Organic matter reacts with the titanium dioxide and sunlight in photocatalytic cleaning, and the surface is hydrophilic, so water spreads in an even sheet across the glass, and removes any organic matter as it washes away. Also in practical use is sunscreen containing titanium dioxide which has a high UV protection rating, and there is no extra whitening as the size of these particles is so small.

These different areas of nanotechnology can all be used on the front line to treat casualties of war and in aftercare in many ways.

To begin with, we believe that a useful application of this technology is in the restructuring of bones that have been shattered or broken in combat. Such injuries are difficult to treat as the damage is so severe that amputation can be needed. However, using nanotubes the bones can be held together as in scaffolding and while healing can be supported by these lightweight structures. A big advantage towards using nanotechnology in this way is that the nanotubes are very strong so can cope with the stress of repairing bones, however unlike current splints do not weigh the leg down. Furthermore, the nanotubes can easily be kept in place until the bone has healed completely and ensure that the bone has healed correctly, whereas a splint must be removed before the bone has completely healed. The nanotubes can also be used on practically any bone, no matter how small, including fragments of bone that shrapnel can shatter from the original bone, and also areas on the body which are composed of many small bones like the hands and feet, so there will be a reduced chance of losing dexterity in severe injuries of these areas.

Another major issue at war is risk of damage to sensitive areas such as the eyes and brain, from bombs, bullets and debris penetrating the skull. However using nerve repair technology that is currently in development any injuries that result in severed nerve

connections, for example blindness, could be repaired to close to the same standard as before any damage. While this is difficult to perform while in areas of war it is a good option for aftercare for wounded soldiers who have returned as casualties. This technology could also be used to treat brain damage, and also restore broken nerve connections in the brain that lead to other parts of the body like the limbs. An asset to these methods is that quality of life can be significantly improved for people suffering from nerve injuries as a result of combat. Another convenience of restoring nerve connections using nanotechnology would be that once the treatment has been given no additional surgery should be needed, simply just checkups ensuring the treatment had been successful.

Nanobots can also be very useful in the field of war. A risk involved in combat is small foreign bodies getting into the body and causing infection or damage to internal organs. Using remote control Nanobots, these foreign bodies can be removed potentially more quickly and easily than typical invasive surgery. Adding to this, nanobots can have nanotubes that are needle-like and can penetrate specific cells and areas, meaning there is less invasion of healthy tissue, which is essential for casualties of war who have lost a lot of blood or injuries where unnecessary damage to tissues needs to be avoided, for example, within the brain. Nanobots could also contain antibiotics or other drugs within carriers such as buckyballs which can help to combat infection or damage. General surgery could also be performed more precisely and quickly using this technology, without the need for incisions, which could potentially become infected in areas with a poor standard of hygiene. Nanobots can also identify small internal injuries faster and more accurately than they can currently be detected. As oppose to heavy surgical equipment, nanobots can be transported easily, dues to their size and weight, meaning that more surgeries can be performed on site, rather than having to move casualties to other countries or hospitals, which can prevent conditions worsening in critical injuries.

As previously mentioned, technology is already in place regarding self cleaning glass. If this could be applied to surgical instruments, then when resources such as sterilising chemicals and equipment are scarce, tools can still be used and easily cleaned by leaving them in sunlight and dipping them in water. This can be very helpful because infection can occur so easily in places of poor hygiene such as areas at war, and having clean tools means that fewer bacteria and viruses will be passed on once incisions are made. This also means that fewer tools will be needed, as currently `one-use` instruments are used, and as oppose to shipping out many scalpels that are unable to be cleaned, nanotechnology can provide one scalpel which can be used many times over, meaning there is less of waste of resources required to make instruments.

Nanotechnology can be helpful in other areas of surgery, for example anaesthetics and pain relief, which are a very important aspect of treatment at war, as pain relief can be crucial in comforting the patient, while anaesthetics allow for immediate surgery, which can be crucial if someone is critically injured. These can be administered in buckyballs, and by inserting carbon nanotubes directly into the bloodstream. This is beneficial because when orally administered, drugs are protected from the stomach acid by the buckyballs, so are not destroyed, and can therefore pass into the bloodstream far more efficiently. This could help on the front if a drug needed to be administered quickly but a vein on a casualty is difficult to find. By creating buckyballs able to recognize certain cells, anaesthetic can be localised, meaning that the rest of the body need not be put through unnecessary stress, this reduces risk of anaesthesia related complications. If administered using nanotubes directly to the bloodstream, not only would anaesthesia be quick and simple to introduce to the body, as

this method bypasses the digestive and respiratory systems, but there would also be a greatly decreased risk of infection, as the nanotubes are so small no bacteria or viruses are able to make it into the bloodstream as well. The quick application of a simple chip also means a fast reaction to the drug, so that surgery is able to be carried out as swiftly as possible after an incident. Pain relief can also be delivered in these ways, which will help to calm a casualty and reduces the effects of shock, making it easier to communicate with a sufferer as well as make them more comfortable and take away their pain.

A common injury resulting from explosive devices is severe burns, which have the potential to become infected, especially in areas where proper medical treatment is not readily available, sometimes causing toxic shock syndrome, which can be fatal. However the burns dressings that have been mentioned above can help to address this problem immediately after a burn becomes infected. By having medics and doctors carrying supplies of these burns dressings not only can infection be spotted straight away from the dye produced when the bacteria attack the nanocapsules, but the antibiotics provide an immediate treatment preventing more severe infections until proper medical care can be reached. The dressings could also have incorporated in them harmless chemicals which could react endothermically cooling the area down quickly to prevent further burning of the tissue.

Explosive devices used in war can also result in severe injuries which can result in amputation of limbs. Even though this may always be inevitable, scientists from NASA are researching using nanotechnology in development of prosthetic limbs.

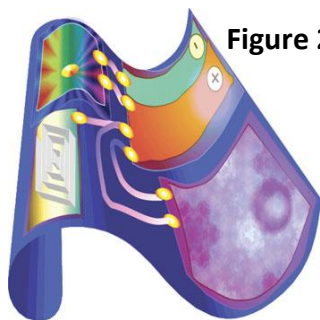


Figure 2

limbs. Their research is based around FILMSkin, shown basically in Figure 2, a revolutionary covering that will allow the prosthetic wearer to feel heat, cold and touch. The skin is made of a polymer and carbon nanotubes, which conduct heat well. By using this, the skin can be made with the ability to feel hot and cold, therefore allowing the wearers to sense when they are touching various different surfaces. This, coupled with the quickly improving bionic technology used to create limbs that the wearers have a wider

range of movement and greater control over, will greatly benefit soldiers who have experienced loss of limbs while serving their countries. It will mean that soldiers have the opportunity to return to a wider range of activities and potential careers, as well as having an improved quality of life. Also, for those self conscious patients, the limb would look more natural, so would attract less unwanted attention. Furthermore, soldiers who wish to return to the army after rehabilitation would be able to take part in a more practical way, and there could be more soldiers with prosthetics returning to front line duty.

However since the army admits different races and religions, there could be religious issues with nanotechnology. Some may believe that creating things by building from atoms is imitating the role of God, as we are “copying nature”, which they believe is not something that humans should become involved with, as they are not his equal. Moreover people may argue that due to the size and accuracy of nanotechnology we could be driving human evolution and changing the natural course of it, which is not how many Gods would wish. Others believe that using people in clinical trials and testing of the new developments is unethical as it could compromise the health and wellbeing of the subject. Some also believe that certain things happen for a reason that, as humans, we do not understand, and by interfering with the outcome of these events you are not obeying the will of God. Many also believe that nanotechnology would reduce the Sanctity of Life of a person, that is, their

relationship and holiness with God. Different faiths also have many different opinions on animal testing, even if it is for the greater good as well, so as nanotechnology will have been tested on animals before humans some people may not agree to this, especially if the treatment of these animals was not humane. Therefore while many soldiers would be happy to see this treatment further developed, some may disagree with it due to their religious beliefs.

Some may also be unhappy that devices such as Nanobots remain in the body after treatment, which may make people feel like their bodies are being observed without them knowing. Therefore these ethical issues would have to be considered when using nanotechnology.

In conclusion, we believe that many of the developments regarding nanotechnology in recent years are very well suited to the variety of injuries and problems that the military face. We think that once the technology has been refined and put forward for public use, the benefits to treatment and aftercare of soldiers would be phenomenal. Using nanotechnology has benefits particular to this field because it can allow a more rapid response than is currently available. Also, the risk of infection could be severely decreased due to the size of the nanoparticles and structures, which are far smaller than bacteria and viruses, and also because of the decreased need for invasive procedures. The development of new nanotechnology could also lead to more advanced ways of aftercare, pain treatment and administration of drugs, improving upon current methods, and causing less pain and distress to the patient.

However, there are some problems with our ideas. Firstly, since nanotechnology is a very recent discovery, there are issues that need to be addressed. Firstly, there are no long term effects known about nanotechnology, therefore problems caused by nanotechnology might not show for a few generations. For example, because the technology is on an atomical scale, it could have repercussions on the DNA of cells, which could potentially cause genetic defects, which would be very hard to correct and would require extensive research. While these problems may not make themselves known for some time, it could be possible to ascertain particles affects on genetic information, if any, in clinical trials with fast breeding animals or bacteria. This means that nanotechnology may be developed accordingly, so that any genetic influence could be avoided. Since this is a problem due to the invasion of cells, it may be a matter of creating particles that cannot pass through cell membranes, and reach genetic information.

Secondly, problems arising from complications with treatments where the nanoparticles are within the body would be hard to deal with as the particles are so small and could be extremely difficult to isolate and remove, meaning that in some cases the problem could not be removed, so might worsen without anything being able to be done. This would be a particular issue in a war environment as many conditions should not be allowed to deteriorate, as this may reduce the time available for the patient to be treated effectively. Doctors and scientists may also have to take into consideration that some nanoparticles may need removing after a certain period of time. One possible solution may be creating particles which dissolve at a certain stage.

There are also economic factors to consider. Because nanotechnology is so intricate and difficult to manufacture, a lot of financing and time are required so that treatments can be developed properly. This creates the problem that some people may not be able to afford such treatments, and people may not be happy that tax is going towards this type of

research. This monetary problem has no outright solution, as newly developed technology will always be expensive, especially since this is a particularly difficult area to engineer products in. In addition, if these treatments were to be used by the army, then not everyone may be able to receive them, and only the worst cases would be eligible for this treatment due to the costs of the procedures. Furthermore, civilians injured as a result of conflict would not be able to be treated in this way, because of the cost, despite the fact that the armed forces may have caused their injuries. Consequently, selectivity could cause problems as it could be difficult to determine who the people most in need are. This is the case with much medical treatment however, and taking into account the economic problems mentioned, it would be up to the discretion of the government or the NHS.

Finally, due to the potential power that nanotechnology carries, when used in the army there is a chance that nanotechnology could be used for the wrong reasons, for example in explosive devices. Therefore the way in which nanotechnology was used would have to be very carefully monitored, so that it does not have catastrophic effects.

Despite these issues nanotechnology has the capacity to make great advances in the field of medicine, especially within the armed forces, as there are many ways that it can be used positively to treat casualties of war in a much more sophisticated way that is quicker and more accurate as the evidence above suggests. By treating injuries both in the field and at home nanotechnology can make a substantial difference.

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