For centuries, medical researchers and doctors around the world have raced to cure cancer, and they have had some success. Their treatment methods have included surgery, radiation, chemotherapy, hormone therapy, and biological therapy (1). With these treatments, they have helped millions of people go into remission. However, the problem with today’s treatment methods is their side effects. Cancer treatments leave patients fatigued, weak, nauseous, and with flu-like symptoms. Additionally, because the treatments target healthy cells in addition to tumor cells, patients also suffer from hair loss and irritated skin. Furthermore, the drug efficacy is low, so patients need a lot of the toxic treatment in order to receive any benefits from it. Fortunately, a revolutionary form of drug delivery is being developed. Scientists are engineering viral nanoparticles, such as the cowpea mosaic virus and the canine parvovirus, to help cure cancer.

How Viral Nanoparticles Work

Viral nanoparticles are emptied virus cells that can carry drugs directly to cancer cells to kill them. Scientists have engineered viral nanoparticles from plant viruses, insect viruses, and animal viruses (2). They avoid using human viruses in order to minimize the chance of the virus interacting with human proteins and causing toxic side effects, infection, and immune response. Mostly, the scientists work with plant viruses, because they are easiest to produce in large quantities (2). Plant viruses are also ideal, because they can self-assemble around a nanoparticle in vitro and hold approximately 10 cubic nanometers of particles (3). Therefore, many molecules of cancer drugs can fit in plant viral nanoparticles.

Many researchers have worked with the Cowpea mosaic virus, a viral nanoparticle about 30 nanometers in diameter created from a plant virus. Keith Saunders, a researcher at the John Innes Center, reported the first Cowpea mosaic virus generated through proteolytic processing. Saunders used plant cells to create Cowpea mosaic virus nanoparticles that were empty of RNA, meaning that the particles would be unable to infect organisms. Saunders also found that by creating the virus particles in plant cells, there was no danger to the structure of the capsid. This would provide more opportunities to create mutations that allow for changes in the protein coating, which would in turn expand the possible uses of nanoparticles. (4)

One of the major benefits of using viral nanoparticles in a drug delivery system is that molecules can easily be attached to the nanoparticles’ surfaces to enable the virus cells to bond only to the cancer cells, rather than the surrounding cells. Pratik Singh, a researcher at The Scripps Research Institute, studied the canine parvovirus and tumor specificity in viral nanoparticles. Singh found that the transferrin receptor on the canine parvovirus responded to transferrin released in human bodies, even though it is a canine virus (2). In humans, transferrin is released during cell growth, so tumor cells have a lot of transferrin receptor expression. The increased expression in tumor cells attracts the canine parvovirus. If the canine parvovirus is filled with a...
drug to kill cancer cells, it would become a tumor-specific drug delivery system (2). Tumor cells express increased levels of other substances too, such as integrins. If viral nanoparticles are coated in a substance that bonds with integrins, they would be as tumorspecific as the canine parvovirus (3). Once the nanoparticles attach to the tumor cells, they can release whatever drug they contained and kill only the tumor cell. Alternatively, an imaging agent attached to or encased within the nanoparticles would allow scientists and doctors to image the tumor after the nanoparticle has attached to it (5).

Another way to draw the nanoparticles to the cancer cells is through attaching iron oxide to the viruses and using magnets to attract them to the tumors. Alfred Martinez-Morales attached iron oxide nanoparticles to the Cowpea mosaic virus and found that the groupings of iron oxide nanoparticles had large magnetic dipoles and increased magnetic field strength (6). These characteristics would allow the Cowpea mosaic virus to be drawn to the tumors by an external magnetic device, thus facilitating imaging and targeted drug delivery.

Challenges

While viral nanoparticles are useful in their specificity, there are some problems with using them for drug delivery. As viruses are made of proteins, the human immune system will attack the viral nanoparticles, even though the viruses that scientists are experimenting with now are non-human viruses. Thus, the viral nanoparticles cannot have repeated use. Researchers at The Scripps Research Institute are currently looking into ways around the immune system’s response by coating the viral nanoparticles in a special polymer substance to mask their protein composition. (2)

Another problem, which has not been as extensively researched, is the toxicity of the viral nanoparticles once they are in the body. Most human viruses have been found highly toxic when used as viral nanoparticles. However, when Singh investigated the toxicity of the Cowpea mosaic virus in mice, he found it to be safe and non-toxic. Non-human viruses tend to have lower toxicity when used as nanoparticles in cancer treatment. (7)

However, viral nanoparticles of either type that have iron oxide connected to them have a much higher chance of being toxic to the body. Iron oxide, a substance that is not biodegradable, cannot leave the body unless the particles are extremely tiny, under five nanometers in diameter (3). More research is needed on how to break up the iron oxide particles that might be attached to a plant virus so that the particles can leave the body.

Conclusion

Viral nanoparticles could revolutionize cancer treatment, acting not only as a safer, more specific form of cancer treatment, but also as a new imaging tool. The nanoparticles could create a type of drug delivery that is extremely tumor-specific with greatly reduced side effects. The viral nanoparticles would be more soluble and have higher drug efficacy than current treatments. The ease with which molecules can be attached to the viral nanoparticles and in turn fuse the nanoparticles to cancer cells is one factor that makes the nanoparticles tumor-specific. In the future, viral nanoparticles used in this form of cancer treatment could allow cancer patients to continue to lead relatively normal lives. The patients would no longer have to suffer the humiliation of hair loss or long bouts of fatigue that prevent them from doing what they love. Rather, the viral nanoparticles would take medication straight to the tumors and kill only the cancer cells, leaving the surrounding cells healthy.

References