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MEDICAL COLLEGE OF WISCONSIN

Healing with Light Moves Beyond Fiction

Fans of the Star Trek television shows can recall many stirring scenes of medical officers treating patients without drugs or surgery, using instead a device the size of a cell phone that sends out light rays to "miraculously" heal wounds and cure disease before their very eyes.

Now, the use of light emitting diodes (LED) in the practice of medicine has moved well beyond science fiction and into the real world. Soldiers injured by lasers in combat, astronauts in space and children in cancer wards are already benefiting from the healing properties of near-infrared light in ways that could only be imagined a few years ago. Several research projects at the Medical College of Wisconsin are at the center of LED treatment development and the application of new technology to a wide range of injury and illness.

"The potential is quite endless," said **Harry T. Whelan, MD**, Medical College Bleser Professor of Neurology, Pediatrics and Hyperbaric Medicine. "I like to say that the history of medicine, since the beginning of time, has been poisons and knives. Drugs usually poison some enzyme system for the benefit of the patient. Think about the drugs you take: Digitalis is digitoxin; it's from the foxglove plant and it poisons your heart gently to help you with cardiac disease. Motrin and aspirin basically poison the prostaglandin system to decrease pain by poisoning the inflammatory cascade. Blood thinners basically poison the clotting system, and on and on and on.

"So all these drugs that we take are poisons carefully dosed to help the patient. And then, of course, knives. That's surgery, in which you have to cut the patient in order to cure. In this particular strategy, what we're trying to do is use the energy of certain specific wavelengths of light, which are carefully studied in our research lab, to determine those that will enhance the cells' normal biochemistry instead of poisoning something that is supposed to occur or cutting at it. I consider that a paradigm shift in the entire approach to medicine that has the potential, therefore, to alter all kinds of disease processes, particularly any in which there's an energy crisis for the tissue."

Light emitting diodes - commonly used for clock displays and in many other electronic devices - produce near-infrared light, a form of energy just outside the visible range. Cells exposed to LED light in this range have been found to grow 150% to 200% faster than cells not given and LED "bath" because, in simple terms, the light arrays speed up the healing process by increasing energy inside the cells.

Relief for Young Cancer Patients

Much of the research into the use of LEDs in medicine has spun off from projects funded by the Defense Department and the National Aeronautics and Space Administration (NASA). For example, when LEDs worked well in providing light to grow plants on the Space Station, researchers found that the diodes also showed promise in many medical applications.

NASA then funded Medical College research and clinical trials using LEDs to treat cancer patients following bone marrow transplants. Mucositis, a very painful side effect of cancer treatment, produces throat and mouth ulcerations and gastrointestinal problems so severe that health suffers as chewing and swallowing food and drink become difficult or even impossible. In the first trial at Children's Hospital of Wisconsin, LED treatment proved so successful in treating mucositis in the young patients that another round of trials has been funded.

"We have now at Children's Hospital essentially prevented mucositis since we've been treating these patients once a day for eighty seconds with our handheld light emitting diode arrays," said Dr. Whelan. "Now we have the FDA (Food and Drug Administration) in collaboration with us performing a multi-center trial throughout the United States and several foreign countries. If we can replicate the results in other centers and reproduce that same data, which we have published, that will become the standard of care. I contacted the FDA when we had achieved these results, because it was pretty dramatic and we were actually surprised by how well it worked. We're already well into the multi-center trial and we anticipate being done in five years.

"If a patient has cancer and you treat with the (current) standards, which are surgery, radiation and chemotherapy, in some case you can cure the patient with standard treatment, which is great. Then there will be those who have recurrences and you escalate into more and more aggressive experimental therapies to try to save their life. Eventually, if you can kill the cancer no other way, you give a lethal dose of chemotherapy and radiation to kill the tumor.

"But then, so you don't kill the patient, you rescue them by giving them a bone marrow transplant that replaces the red blood cells and the white blood cells so you don't have clotting problems and bleed to death or die from overwhelming infection or severe anemia. It does not rescue the mucous membranes, the kidney, the liver, or all kinds of other areas where high-dose chemotherapy and radiation can lead to side effects. The mucous membranes in particular become sore, hemorrhagic, and extremely painful. This prevents the patients from eating or drinking anything so they become dependent on intravenous feeding and wracked with pain in bone marrow transplant isolation wards."

LEDs on the Battlefield

As a leading researcher in the general field of LED treatment, a pediatric neurologist, and a medical officer in the US Naval Reserves with an extensive background of various active duty military medicine postings, Dr. Whelan speaks enthusiastically about positive outcomes that may have their beginnings on battlefields or in space but end up being applied in places like the Children's Hospital cancer unit. He is principal investigator for the "Persistence in Combat" research program at the Medical College, a program of the Defense Advanced Research Projects Agency (DARPA).

"DARPA was created in 1956 when the Russians launched Sputnik," said Dr. Whelan. "The US government established this agency to start a space program to catch up with the Russians before they put bombs above us. Then our own Congress decided that they didn't want the military in this country to control space either, so shortly thereafter they spun off NASA. DARPA continues to exist and is important for research. They look for high risk, high gain projects, things that are so crazy that

they might not work but if they do it's really good. I like DARPA because they're interested in doing science like I thought it would be cool when I was a kid, not science that's boring.

"In the Defense Department work, the idea is rapid battlefield care, self-care being the optimum. If you're in a modern special operations scenario, you're in a small rapidly mobile unit expected to be self-sufficient that may not be evacuated for over 96 hours if there are casualties. You will not be able to get to M.A.S.H. units or hospitals. If you're lucky enough to have a medic or a corpsman, he may be the first casualty. So what do you do? If you need to fight back because the alternative is to be killed, it's important to be able to treat problems yourself.

"So, we have developed hand-held prototypes that are currently deployed in the Middle East and being tested on patients with various casualties, most notably laser eye injuries. Laser eye injuries are a new emerging battlefield threat. There are many unclassified stories about our troops in Bosnia, Iraq, Afghanistan and North Korea that have been shot with lasers with the intent to blind, as well as the occasional inadvertent military laser injury with a range finder."

Dr. Whelan led a study on using LEDs to reverse blindness in rats that was published in the Proceedings of the National Academy of Sciences (Vol. 100, March 18, 2003) and was inducted into the NASA Space Technology Hall of Fame in 2001 for his LED research, indicators that the progression in this area from science fiction to "real science" is complete. The Bleser Foundation endows his professorship, and the Chad Baumann Charitable Trust has also provided funding for the LED cancer treatment research.

Overcoming the Impact of Weightlessness

"In our NASA projects what we're trying to do is find ways to use the energy of near-infrared light to stimulate the little engine in every cell, which is the mitochondria, so that the drive train, which absorbs these very wavelengths of light energy, can be powered to do what it's best at doing, which is providing energy for the cell to do everything it does," said Dr. Whelan. "Now, light absorbed by, say, your sweater or my black pants, does not automatically convert into biological benefits. But if it's absorbed in the form of light energy by chemicals whose job is always to make use of energy to power the cell, then it's going to maybe be put to good use. That's what we will do.

"Astronauts get four problems. They get immune deficiency, pituitary insufficiency that leads to hormone imbalances in space, wound healing delays, and muscle and bone atrophy. If we can use energy to counteract the long-term effects of weightlessness, which causes a distortion of the mitochondrial structure or scaffolding architecture, then maybe we can countermeasure these four problems astronauts get by long-term weightlessness. That's the NASA thing. It's a long-term preventative daily treatment with this near-infrared light to help 'goose' their cells into better health to overcome the problems of chronic weightlessness on the cell."

While not all cells react to near-infrared light in the same way, Dr. Whelan and others anticipate testing LED therapy in other areas such as organ and tissue regeneration, stroke, spinal cord injury, brain tumors and Parkinson's disease.

"If you think about it, a lot of injuries result in an energy problem because the tissue is damaged, injured, and therefore has difficulties going through its normal processes of energy metabolism," said Dr. Whelan. "Usually there's a lot of swelling, which strangles the blood vessels. You're getting inadequate oxygen and nutrients, so there's an energy crisis. If there's a critical time, and as a neurologist I'm particularly conscious in the case of stroke, spinal cord injury and in the case of retinal laser injury as in the DARPA project, it's those golden hours during which tissue that hasn't been completely destroyed is fighting for survival.

"(LED) might make the difference between a small stroke or a large stroke, or between Christopher Reeve being paralyzed for life or walking again, or between someone having a tiny little blind spot from where the laser first hit to being completely blind because of the spreading injury around the entirety of the retina. Those are the differences we'd like to make in neurology, and those things can have spin-offs beyond military combat casualty care to things like diabetic retinopathy, diabetic ulcers, other tissues that can be affected, metabolic diseases where the mitochondria is the area of tissue affected by the problem, serious burns, and then a whole host of neurologic injuries. These are all potential future areas."

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For more information on this topic, see the HealthLink article Light Emitting Diodes Aid in Wound Healing.

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MCW Health News presents up-to-date information on patient care and medical research by the physicians of the Medical College of Wisconsin.