Medical Applications of Space Light-Emitting Diodes Technology---Space and Beyond

Abstract:

Space light-emitting diode **(LED**) technology has provided medicine with a new tool capable of delivering light deep into tissues of the body, at wavelengths which are biologically optimal for cancer treatment and wound healing. This **LED** technology has already flown on space shuttle missions, and shows promise for wound healing applications of benefit to Space Station astronauts and in special operations.

The full-length article is available in Space Tech. & App. Int'l. Forum -1999, vol 458:3-15. 1999-00, Medical College Of Wisconsin

Wound Healing

Wounds heal less effectively in space than here on Earth. Improved wound healing may have multiple applications which benefit civilian medical care, military situations and long-term space flight. Laser light and hyperbaric oxygen have been widely acclaimed to speed wound healing in ischemic, hypoxic wounds. Lasers provide low energy stimulation of tissues which results in increased cellular activity during wound healing. Some of these activities include increased fibroblast proliferation, growth factor synthesis, collagen production and angiogenesis. Hyperbaric oxygen therapy has also been shown to affect these processes.

Lasers, however, have some inherent characteristics which make their use in a clinical setting problematic, including limitations in wavelength capabilities and beam width. The combined wavelengths of light optimal for wound healing cannot be efficiently produced, and the size of wounds which may be treated by lasers is limited. Light-emitting diodes (LED's) offer an effective alternative to lasers. These diodes can be made to produce multiple wavelengths, and can be arranged in large, flat arrays allowing treatment of large wounds.

Our experiments suggest potential for using LED light therapy at 680, 730 and 880 nm simultaneously, plus hyperbaric oxygen therapy, both alone and in combination, to accelerate the healing process in Space Station missions, where prolonged exposure to microgravity may otherwise retard healing.

Studies on cells exposed to microgravity and hypergravity indicate that human cells need gravity to stimulate cell growth. As the gravitational force increases or decreases, the cell function responds in a linear fashion. This poses significant health risks for astronauts in long term space flight.

The application of light therapy with the use of NASA LED's will significantly improve the medical care that is available to astronauts on long term space missions. NASA LED's stimulate the basic energy processes in the mitochondria (energy compartments) of each cell, particularly when near-infrared light is used to activate the color sensitive chemicals (chromophores, cytochrome systems) inside. Optimal LED wavelengths include 680, 730 and 880 nm. Our laboratory has improved the healing of wounds in laboratory animals by using NASA LED light and hyperbaric oxygen. Furthermore, DNA synthesis in fibroblasts and muscle cells has been quintupled using NASA LED light alone, combining 680, 730 and 880 nm each at 4 Joules per centimeter squared

Muscles and Bones

Muscle and bone atrophy are well documented in astronauts, and various minor injuries occurring in space have been reported not to heal until landing on Earth. Long term space flight, with its many inherent risks, also raises the possibility of astronauts being injured performing their required tasks. The fact that the normal healing process is negatively affected by microgravity requires novel approaches to improve wound healing and tissue growth in space. NASA LED arrays have already flown on Space Shuttle missions for studies of plant growth. The U.S. Food and Drug Administration (FDA) has approved human trials. The use of light therapy with LED's is an approach to help increase the rate of wound healing in the microgravity environment, reducing the risk of treatable injuries becoming mission catastrophes.

Special Operations

Special Operations are characterized by lightly equipped, highly mobile troops entering situations requiring optimal physical conditioning at all times. Wounds are an obvious physical risk during combat operations. Any simple and lightweight equipment which promotes wound healing and musculoskeletal rehabilitation and conditioning has potential merit.
NASA LED's have proven to stimulate wound healing at near-infrared wavelengths of 680, 730 and 880 nm in laboratory animals, and have been approved by the U.S. Food and Drug Administration (FDA) for human trials. Furthermore, near-infrared LED light has quintupled the growth of fibroblasts and muscle cells in tissue culture. The NASA LED arrays are light enough and mobile enough to have already flown on the Space Shuttle numerous times.
LED arrays may be used for improved wound healing and treatment of problem wounds as well as speeding the return of deconditioned personnel to full duty performance. Examples include:

1. promotion of the rate of muscle regeneration after confinement or surgery.
2. personnel spending long periods of time aboard submarines may use LED arrays to combat muscle atrophy during relative inactivity.
3. LED arrays may be introduced early to speed wound healing in the field.
4. hyperspectral sensors being developed at NASA Stennis Space Center by ProVision Technologies may provide early evidence of wound healing problems and monitor the effectiveness of LED treatment.

Our laboratory gratefully acknowledges the contributions of
LT Christopher J. Cassidy, USN
who serves as the U.S. Navy SEAL Advisor to this project.
Naval Special Warfare Group TWO Medical Consultants:

- LCDR Alan F. Philippi
- LCDR Pete Johnson
- LT Geoffrey M. Fitzgerald