News
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***Effects of heat on man provides framework for new book

DALLAS--Deep sea divers, astronauts and firefighters all know that severe injury or death occurs quickly unless they have adequate protection against the extreme temperatures in which they work.

Fluctuations in temperature within the body, such as high fever, can also have the same results.

In fact, even ancient physicians perceived the importance, for health, of stable internal temperatures and a moderate climate. More recently, man's excursion into extreme environments, such as space, and the application of therapeutic heat and cold have focused more attention on the prediction and measurement of the internal temperature distribution in humans.

With these applications has come the realization that there has been no comprehensive, mathematically based analysis of the distribution of heat in man. This has led Dr. Robert Eberhart and Dr. Abraham Shitzer to develop computer models for the analysis of internal temperature distributions resulting from these new applications. Eberhart is chairman of the Joint Program of Biomedical Engineering at The University of Texas Health Science Center at Dallas and at UT Arlington. Shitzer, who collaborated on this work while on a sabbatical at UTHSCD, is professor of Mechanical Engineering at the Technion, Israel Institute of Technology in Haifa, Israel.

Their mathematical analyses and the contributions of several other experts in biological heat transfer have culminated in a two-volume book set entitled Heat Transfer in Medicine and Biology. Dr. James Lipton, professor of Physiology at the health science center, and an internationally recognized researcher in fever therapy, has also contributed a chapter.

"From now on, using the computer models and other types of models included in the book, we should be able to more accurately predict the temperature distribution within the body," said Eberhart. The work provides a firm, theoretical foundation for the increasing number of medical and biological applications in which temperature plays a major role. Extensive data tabulations and other descriptions of experimental work complement the theoretical work, making Heat Transfer in Medicine and Biology a complete reference for researchers and clinicians.

Of current interest is the description of hyperthermia, or thermal dosimetry, a technique in which heat is delivered into a tumor in an effort to destroy it. Using the computer models, doctors will now be able to predict more precisely the intensity and duration of heat application necessary to destroy the tumor without causing damage to surrounding tissue.

(over)

Controlled hypothermia is also covered in the book. The technique is used during surgery to protect the cells by reducing metabolism. In selective circumstances it is combined with circulatory arrest to control bleeding. Applying models presented in the book, significant findings concerning the body's exchange of heat during these procedures has already been uncovered. Dr. Robert Olsen, a Biomedical Engineering student of Professor Eberhart, used the heat transfer theories developed in the book. He discovered that while in this hypothermic state, the brain is rewarmed by residual pockets of heat left throughout the head, not from the environment nor by metabolic heating, as previously believed. This rewarming was actually a result of imperfect cooling. The residual heat, conducted into the brain, presents a potential danger to the viability of cells. The body's metabolic rate changes exponentially with change in body temperature (a 10°C increase in temperature increases metabolism about 2.5 times). The rewarmed brain metabolizes at a faster rate, owing to the increasing temperature. Since metabolic stores are not replenished during the arrest state, their consumption threatens cell viability throughout the body. Olsen's extensive research suggests ways to extend the length of time a patient can be safely maintained in this arrested state by cooling the patient more completely and ridding the body of all heat pockets. This enables surgeons to perform more complicated, definitive surgery with less trauma to the patient. It also helps surgeons predict the exact point at which irreversible tissue damage would begin.

The heat transfer applications can also be used to a great extent in predicting effects of hostile environments on man. The models can be applied, for example, to firefighters, astronauts and deep sea divers to improve the understanding of the dangers of prolonged exposure in such environments.

The book may also pave the way for advanced techniques for freezing and thawing tissues so that they can be stored for long periods of time.

In burn analysis, the computer models will enable doctors to better diagnose the true extent of burn wounds and develop methods to provide more effective treatment.

Understanding how heat and cold affect people will have far-reaching benefits for many other areas, including electrosurgery, laser surgery, cryosurgery, thermography, exercise physiology, and heat-illnesses such as fever and heat stroke.

Says Eberhart: "Engineers are now simulating the thermoregulatory control system that nature provides; this is being built into computer models to predict the response of the central nervous system to episodes of selected heating and cooling." Using computers is a more ethical way to do thermoregulatory studies, he says. "We are using computers for models instead of patients themselves.

"We have attempted to provide a mathematical framework for heat transfer and thermoregulation in man, using practical studies of clinical importance that will be useful in numerous settings."

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