Ice slurry technology can save heart attack victims, surgery patients

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Argonne researchers have created a bio-compatible saline ice slurry that could save lives by preventing ischemic damage to organs during surgery or certain types of medical crises.

(PhysOrg.com) -- When treating cardiac arrest victims, doctors can't call a time-out. Without the ability to obtain fresh oxygen from blood pumped through the body, brain cells start to die in just minutes. Within 10 to 20 minutes after the heart stops beating, the clock has run out. Even if doctors can get the heart ticking again, the brain has died.

Recently, however, researchers have begun to develop a new technique that can reduce the brain and other organs' demand for oxygen, giving doctors precious extra time to diagnose and treat critical patients in emergencies while also protecting the heart, brain, kidneys and spinal cord in planned surgeries.

Scientists in the Nuclear Engineering Division at the U.S. Department of Energy's Argonne National Laboratory have created an ice slurry – a slushy substance that somewhat resembles a 7-11 Slurpee®. This slurry can be pumped easily into the body through a small intravenous (IV) catheter directly into a patient's bloodstream.

Argonne is working with the several different groups of University of Chicago surgeons to develop procedures for cooling and protecting vital organs. This research is being conducted under a newly formed University of Chicago-Argonne Bioengineering Institute for Advanced Surgery and Endoscopy (BIASE).

Argonne researchers designed and patented the equipment used to produce the slurry, which is delivered into the body by specially designed tips. Doctors can quickly chill the targeted organ by choosing one of several possible routes for the slurry based on the condition to be treated. This cooling reduces an organ's need for oxygen, slowing the rate at which cells asphyxiate and providing doctors more time for treatment.

In the case of a victim who suffered cardiac arrest out of a hospital, the slurry would be delivered to the lungs through an endotrachea tube. Paramedics would then administer chest compressions, which would force blood through the cold lungs. From there, the chilled blood would pass through the carotid arteries and into the brain, cooling it rapidly.

For several decades, doctors have recognized the benefits of protective cooling for certain classes of patients. In the past, however, doctors relied on external cooling approaches – ice baths and cooling jackets, for example -- to induce protective hypothermia. These techniques lacked two of the advantages of the ice slurry.

Most importantly, external cooling acts much more slowly, greatly hampering its effectiveness. While the ice slurry can cool the core of an organ by nearly five degrees Celsius in only five minutes, external cooling can take more than two hours to have the same effect. In addition, doctors can target individual organs by delivering the slurry internally, which reduces the risk of secondary adverse effects including shivering and possible arrhythmia, according to Argonne engineer Ken Kasza.

"Current medical guidance says that if you want to save the brain, you have to lower its temperature by four or five degrees Celsius within five to 10 minutes of cardiac arrest if paramedics can't restart the heart," said Kasza, who led the development of the slurry production and delivery technology. "For the first time, we have a means of attaining the necessary temperature in that short span of time."

Kasza originally started to develop ice slurries for industrial cooling, where they would be pumped through pipes ranging in size from six to 60 inches in diameter. Under a joint Argonne-University of Chicago Emergency Resuscitation Center collaboration funded by a National Institutes of Health grant, Kasza further developed the slurries for cooling and protecting cardiac arrest victims.

More recently, Kasza and his Argonne colleagues Yue Wu, Chuck Vulyak , Adrian Tentner and Paul Fischer have teamed up with surgeons at the University of Chicago under BIASE, to further develop and demonstrate the use of ice slurries for protective cooling during several types of surgery. The three surgical applications for ice slurry cooling focus on minimally invasive laparoscopic kidney surgery, cardiovascular surgery and surgeries that would otherwise risk neurological damage to the brain and spine.

According to Kasza, minimally invasive laparoscopic kidney surgery represents the "lowest-hanging fruit" for initiating clinical trials of protective ice slurry cooling. Because this type of operation almost completely cuts off the blood flow to the kidney, rapid cooling could give doctors the precious extra time they need to perform the operation without risking damage.

Kasza and University of Chicago surgeon Arieh Shalhav have already explored the use of ice slurry cooling in kidney surgeries on large animals with promising results, and they plan to seek FDA approval for human trials. In the near future, Kasza hopes to find a biomedical company interested in commercializing the slurry production and delivery equipment technology. "Ideally, we want to entice the private sector to invest in this life-saving technology," he said.

If researchers can prove that the slurry can protect an array of organs during a variety of surgical procedures, they might eventually be able to use it to stabilize soldiers who sustain severe injuries on the battlefield. Since troops in battle lack access to immediate and sophisticated medical care, these casualties have heretofore been almost universally fatal. However, Kasza said, many medical researchers believe that by chilling the body's core to just a few degrees above freezing, doctors can keep patients in temporary stasis until they can receive the necessary medical intervention.

In order to more efficiently and safely introduce the slurry into a patient's body for a given application, Kasza, Tentner and Fischer have begun to use three-dimensional models and computer simulation to analyze the thermal interaction between slurry and tissue. These models give scientists the ability to simulate and visualize the heat exchange and blood flow within target organs and calculate how quickly and uniformly they are cooled to protective levels.

The researchers also plan to develop simulations of the entire circulatory system in order to quantify the cooling effect of the slurry on major organs that are not the direct target of the surgical procedure but that may still require protective cooling during surgery. The computer simulations ultimately will also give surgeons the ability to tailor protective cooling treatments to the needs of individual patients, Kasza said.

"In the emergency and surgical situations that we're dealing with, time frequently is the most valuable resource we have," Kasza said. "By understanding the complex interactions between the slurry and the vulnerable organs, we can optimally induce protective cooling and save lives."

Provided by Argonne National Laboratory

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