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Protective Hypothermia: Medical Ice Slurry Technology

DEVELOPING TECHNOLOGY USING A MEDICAL ICE SLURRY AND HOW IT CAN SAVE LIVES

ReachMD would like to wish you a happy and healthy New Year and with each New Year comes a fresh start. As we look ahead, ReachMD is proud to present this month's special series - Focus on Future Medicine.

During cardiac arrest if you want to save the brain, you have to lower its temperature by 4 to 5 degrees Celsius within 10 minutes of the event. Scientist at Argonne National Laboratory in conjunction with the University of Chicago have successfully developed ice slurry that can be pumped into the body to protect specific organs during a health emergency. Welcome to a special program focusing on the future of medicine. I am Dr. Larry Kaskel, your host, and joining me today is Dr. Ken Kasza, a Senior Engineer within the Development and Application Department at Argonne National Laboratory to discuss the developing technology at medical ice slurry and its lifesaving application.

DR. LARRY KASKEL:

Dr. Kasza, welcome to the show.

DR. KEN KASZA:

Good afternoon.

DR. LARRY KASKEL:

Before we talk about the development of this ice slurry, can you tell me a little background about this tissue protective cooling mechanisms?

DR. KEN KASZA:

In the area what we call cell protective hypothermia, the idea is that cells if they are not furnished with adequate oxygen or for example in cardiac arrest no oxygen because there is no blood flow the oxygen is required basically for metabolism and for the cell health. It basically is the ingredient for all the normal life cycles and the things that are happening within the cell itself, all of those processes that

are happening within the cell are basically controlled chemical process. They are strongly dependent upon the temperature at which the processes take place, so we protectively cool something what we are doing is lowering the temperature of a tissue, which is comprised of the cells. The cells need for oxygen due to the very highly reduced chemical reaction rates it goes down dramatically and so in effect the cells are happy with much lower oxygen levels and you slow down the death process associated with lower or no oxygen.

DR. LARRY KASKEL:

So who is interested in this, I know this has been going on for at least 20 years ago, where is your funding from?

DR. KEN KASZA:

In my area, the area I have been working I got involved about 9 years ago. The initial money for protective cooling was not for protective cooling of humans. It was basically for industrial cooling applications, cooling of large buildings and I was funded by the Department of Energy. About 9 years ago, Argonne National Laboratory and the University of Chicago Medical School wanted to increase their collaboration in various medical areas. We had some brainstorming sessions and one of the doctors heard about our ice slurry that could be pump fairly easily in industrial systems, we then discussed how we might use it in medical applications. The initial doctors we worked with were emergency room physicians and researchers and one of their fundamental problems was cardiac arrest patients especially out of hospital cardiac arrest where they have had a heart attack and in the US the survival rate for out of hospital cardiac arrest is 5% normally of that level and typically what the emergency room physicians their problem is that a patient out of hospital is first seen by paramedics they try de-fibing maybe 3,4, or 5 times and quite frequently they cannot restart the heart, so you either pronounce dead in the field or you are taken back to an emergency room and occasionally in the emergency room they will restart the heart, but there has been no blood flow to the brain for 10, 15, 25, 30 minutes depending on the journey, and even with chest compressions, the brain has started to die, so in the hospital they restart the heart and you are brain dead, so the general survival rate is 5% of anybody out of hospital with cardiac arrest, so protective cooling people have talked about it, but no one at that time understood how to do it rapidly and quickly. They might try packing the cardiac person in ice, but it's extremely slow process and we need to cool down in 5 to 10 minutes and so we got involved with making of slurry in a way to deliver it in this case to the lungs that was our first example.

DR. LARRY KASKEL:

So what's in the slurry is it ice, water, antifreeze?

DR. KEN KASZA:

The slurry as it now stands is 3 basic types, the more common one that we have been using mostly in lot of our animal studies to date is a saline-based ice slurry. In its simplest form, it's ice that has been chopped up into extremely small particles best within a tenth of a millimeter in size. It's combined in the production process with sterile water and a certain amount of salt and the salt is added, again I don't know what kind of technical detail, but the salt like you put on the side walk to remove ice from your side walk lowers the freezing point somewhat of the ice. With the small ice particles, they need to be very smooth in order to flow like water in this very dense slurry, so the salt in the water when mixed with the ice melts off the micro scale surface roughness and that plus some other conditioning allows us basically to pump it through very small delivery devices deep into the body. We have 2 more types of slurries. We have been able to make slurry composed of ice particles made with a commercially available blood substitute, so we are expanding the medical benefits of slurry. A saline slurry The main benefit is protective cooling, but now when the carrier liquid is for example a blood substitute we have the attributes of a blood substitute added into the slurry cooling effect things like oxygen transport, cell nourishment, so that's a second type of slurry. A third type of slurry we make is an ice particles formed in a fluorocarbon chemical. Fluorocarbon is being explored as a medical conveyance of oxygen for basically putting into the lungs and so we have made slurries with that and in that case there we have ice plus perfluorocarbon plus oxygen that's in the perfluorocarbon liquid and the lungs are actually capable of drawing the

oxygen out of this liquid and so there are basically 3 types of slurries.

DR. LARRY KASKEL:

So it sounds like you can give it endotracheally, you can give it through an IV, are there other ways of getting it into the body?

DR. KEN KASZA:

We have been involved with animal studies to date in several different areas and it's being expanded, so originally it was out of hospital protective cooling for cardiac arrest or even severe stroke problems out of the hospital then we went into laparoscopic surgery and kidney cooling for example where in minimally invasive laparoscopic surgery for example on the kidney there is a clamp off point in time before doing surgical manipulation cutting for example remove a cancerous growth that clamping off process of that kidney basically allows no oxygen carrying blood through the organ, so if they don't cool those organs under that scenario they have 30 minutes of actual operating time that's not very much for a complex surgery, so what we have been doing and demonstrated in large animals is we can make for example our saline slurry and we deliver it through a laparoscopic port is one of may be up to 3 to 4 additional ports for endoscopic viewing and other manipulations, so the surgeon clamps off immediately delivers slurry at a couple 100 mL per minute. He coats the whole bottom, sides, and top of the kidney. Within 5 minutes the kidney is cooled down and they will like to cool quite deeply down below 15 degrees centigrade normal being 37, and within 5 minutes, the organ is protectively cooled and we have established through survival animal experiments protection now to 2 hours so far.

DR. LARRY KASKEL:

If you have just tuned in, you are listening to a special program focusing on the Future Of Medicine. I am Dr. Larry Kaskel, your host, and I am talking with Dr. Kenneth Kasza, Senior Engineer within the Development and Application Department at Argonne National Laboratory and we are talking about a developing technology using a medical ice slurry and how it can save lives.

Has anything been done in humans or is it all been done on animals so far?

DR. KEN KASZA:

The results today have only been done on large animals. You might ask where we at, so we have gone from laparoscopic surgery. We are now working with cardiac and cardiovascular surgeons for protective cooling, that particular application is our strongest challenge because the cardiac surgeon for example if he is pushing a catheter up from the femoral vein down in the leg they have catheters that are up to 100 cm in length and they can be frequently of internal diameter less than 1 mm, so we are working with cardiac surgeons right now to establish the ability to deliver slurry to protect the heart muscle for example from reperfusion damage when doing may be a balloon catheterization to open up a blocked blood vessels and artery. We have established the ability to deliver a saline solution based slurry into those catheters of very small size and deliver it at a rate, which we think is adequate to cool either a sub-sector of the heart muscle or the whole heart muscle itself. Within the next 3 months, we will be getting our first animal studies in that area.

DR. LARRY KASKEL:

When I was in medical school and I watched open-heart surgery, they poured some sort of ice on the heart, what's the difference?

DR. KEN KASZA:

In open chest surgery, I have seen videos especially from Russia 3 to 5 years ago where they had the whole chest opened up, the heart everything is beating there, and they would reach with sterile gloves into a bucket of chunk ice, crushed ice and they will just pack the general area with that ice to cool it down into a protective hypothermia, so that same procedure is currently used in the open cavity laparoscopic kidney surgery like conventional surgery where there is a big opening there and that is how they cool it down, but as I mentioned where in laparoscopic surgery now we have these very small ports you can no longer reach into an ice bucket and pack it around the organ so for example in heart surgeries the trend is towards minimally invasive and in many cases even laparoscopic surgery under robotic conditions. In those conditions, there is no longer the big openings and so the surgeon can no longer reach into an ice bucket, grab a handful, so we are addressing that surgical area of application.

DR. LARRY KASKEL:

It is an exciting field and technology and I look forward to what's to come and I would like to thank Dr. Ken Kasza for talking with us today.

DR. KEN KASZA:

Thank you very much for inviting me and I appreciate the interest in our work.

DR. LARRY KASKEL:

Dr. Ken Kasza is a Senior Engineer within the Development and Application Department at Argonne National Laboratory and he was here talking about a developing technology of medical ice slurry and its lifesaving applications.

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