The Flexible Ultrasound System (FUS)

Detection, Propulsion + Comminution of Kidney Stones with Ultrasound

Narrator: New methods of treating painful, dangerous kidney stones continue to evolve at the Center for Industrial and Medical Ultrasound — part of the University of Washington's Applied Physics Laboratory.

Mike Bailey: The first new kidney stone management in 30 years. A revolutionary treatment.

Narrator: This new treatment is non-invasive and powered by focused ultrasound, providing safe, timely management of kidney stones on Earth and, very soon now, in space.

Bailey: NASA funded us initially to invent this technology — this idea that you could, with the transducer probe pressed up against the skin, use the sound wave force to push the stone, to direct its movement through the passage out of the kidney.

So we additionally got money from NASA to do a clinical trial — the first clinical trial of an invention at the University of Washington by the inventors. FDA approved this study of an investigational device, invented here and conducted here at the University of Washington. It was a very successful trial. We moved stones. We relieved pain in some cases, and we helped stones pass in other cases.

This system here is the Flexible Ultrasound System. We developed it with NASA and GE was actually the vendor that provided it. It's now a GE system available clinically.

Bryan Cunitz: This is a clinical ultrasound system. Normally everything you see right here is rolled into the clinic. This is actually very common in cardiac units of hospitals. The nice thing about having this system is that we're using an up-to-date commercial system with modern probes, modern hardware, and electronics.

Bailey: We had this initial success of pushing stones. And the project has continued to grow from there.

Barbrina Dunmire: We've tested our technology in humans and our ability to move stones out of the kidney. And these are typically fragments – freely-moving stones within the kidney itself. But now we want to look at stones that are obstructed, typically in the ureter either near the kidney or near the bladder, which represents a new challenge for us.

This is an example of your kidney with the ureter. These obstructions are really the emergency conditions that drive people into the emergency room on weekends, nights, and early in the morning. When the stones get stuck, there's a backflow of urine in your kidney that expands the kidney and that is what causes the pain that people experience with kidney stones.

We've actually thought of the idea of using breaking as a way to fragment the stone a little bit and then push it, dispersing the fragments away from each other and allowing them to drop. Burst wave lithotripsy or BWL has also been developed at the University in conjunction with ultrasonic propulsion over the last five years. And we found that integrating the two together actually helps both of them become a more efficient technology.

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Bailey: In addition for NASA, we're developing phantoms to train and study how we break stones or move stones or image stones. This is a kidney phantom. The stone is able to be placed inside. These are some of the model stones that we use or we use real human stones.

Dunmire: We're further developing our technology to grab the stone and be able to drag it along the ureter.

Narrator: Grabbing a stone, in much the same way fictional *Star Trek* space vehicles deployed a "tractor beam".

Bailey: Tractor beam is kind of a colloquial term. It doesn't sound very scientific, it sounds like science fiction. But these acoustic waves can be focused. So they can be focused beyond the stone, next to the stone. And those waves create pressure. And so they can build basically a cage of pressure around the stone. And then as you move the transducer, you can drag the stone with it. Or as you move the beam through refocusing, you can kind of electronically steer that stone.

Narrator: Changes in air pressure or the gas composition of the air we breathe affect the tiny gas pockets that cling to kidney stones. These gas pockets are important for detection, imaging, and breaking.

Julianna Simon: I've been working on kidney stone detection for a while. Ultrasound can be used to detect kidney stones and adding this color-Doppler twinkling artifact that shows the stones as color on a gray-scale image makes it really easy for a non-expert sonographer to be able to identify the stone.

Narrator: But research indicates relatively higher levels of carbon dioxide, such as found aboard the International Space Station, tend to mask the twinkling artifact.

Simon: So now it's much harder to find the kidney stones.

Narrator: Preclinical tests in a hyperbaric chamber are underway to determine these effects.

Simon: We've done several different concentrations of carbon dioxide. We still see the big affect so we're looking at teaming up with NASA to do a human subject trial and see how carbon dioxide affects kidney stone imaging. The idea is that maybe breathing oxygen can be used to enhance twinkling on Earth and in space.

Narrator: The team has also completed preclinical tests with NASA funding to confirm that their burst wave lithotripsy treatment is effective even in a high CO2 environment such as the International Space Station.

In time, this system will be reduced in size to facilitate transport into orbit.

Bailey: This device is largely software-based. So the idea is that researchers would continue to develop new apps.

Narrator: New application software would simply be uploaded to the system aboard the space station. No hardware replacement necessary. The latest in kidney stone management – on Earth and in space.

Science at Work for You

This is APL — The Applied Physics Laboratory at the University of Washington in Seattle.