Burst Wave Lithotripsy

An Experimental Method to Fragment Kidney Stones

Narrator: Bursts of ultrasound acoustic energy chip away at a simulated kidney stone. Researchers at the APL-UW Center for Industrial and Medical Ultrasound are working to develop a safer, non-invasive way to fragment kidney stones so they may pass naturally allowing patients to avoid painful surgery.

Adam Maxwell: What we were thinking was we'd be able to break stones more effectively by not using shock waves, but by using ultrasound pulses. Ultrasound pulses can be generated by a much greater range of technologies. It also doesn't require very high voltages as it does to produce shock waves.

Narrator: Burst-wave lithotripsy uses relatively low peak pressure of the incident sound field. Resonances can cause stresses and fractures in a kidney stone in much the same way an opera singer's voice might shatter a glass.

Maxwell: This is the burst wave lithotripsy therapy system that we're currently working with: it's a working prototype. This is the amplifier system that houses all the electronics to both determine the ultrasound paramaters and produce the power to drive the therapy transducer. The system's guided by ultrasound imaging.

Bryan Cunitz: We have our focal region here in the dotted red line and we can see the stone is centered here and we get this twinkling on it, letting us know that we're actualy targeting the stone.

Maxwell: I was originally an undergraduate in this lab and I started working with Mike Bailey and the first project that I worked on was to do experiments on how kidney stones are broken by shock waves – shock wave lithotripsy.

We were looking specifically at what characteristics of the lithotriptors produced outputs that broke kidney stones better. So the shock is not only impacting the stone, but traveling around the stone. And that really seems to be a key to producing stone fracture.

Wayne Kreider: There's a tensile wave. There's a negative pressure that can cause bubbles to grown. And we typically call that cavitation activity. And when the bubbles grow and colllapse, they do so very forcefully and one of the things that's good for is that those forceful collapses can help to break stones. One of the downsides is that same bubble activity can also break or injure tissue.

In many ways, this is a narrow-band version of shock wave lithotripsy. Shock wave is broadband – a sharp spike of pressure and burst wave lithotripsy, we're using a burst that has a narrow frequency content – rather than like hitting it with a hammer, it's a series of waves with a very narrow bandwidth and that enables you to break up the stone in a way that's more controlled with uniform fragments – which is clinically important.

Maxwell: Our initial experiments were to examine what are the characteristics of how stones fracture this way compared to how they fracture in shock wave lithotripsy. So we were looking at how quickly we can break the stone into small fragments. What size of fragments does it generate? What types of stones can we break?

The other things we're looking at is how do the sizes and shapes of the stones affect how they break?

Madeline Hubbard: Even when you have all that control with the parameters – the ultrasound, the water bath – there's going to be so many types of kidney stones that we run into – both material and size.

We're just looking for – does the effectiveness of treatment vary with the diameter and the length and also are there weird quirks in it?

We want to see what kinds of variations we have. If we can maybe model it in some way so that we can look at a patient's stone diameter and length and say we can effectively break this or we can't effectively break this.

Maxwell: So far, we found out we can treat most stone types. We can treat some of them very rapidly. The softest stones crumble in a few seconds. The hardest stones generally take 10 to 20 minutes. To compare that to a shock wave lithotriptor – treatment is about 30 minutes and can be as long as an hour.

We imagine there is going to be a range of sizes of stones that we can break. We're trying to find the limits of what indications this can be used for.

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