A fast, portable medical lab that could test for COVID-19

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Mechanical engineering Professor Juan Santiago is working to adapt one of his microfluidic tests to detect the presence of the virus that causes COVID-19. Credit: Juan Santiago

Mechanical engineer Juan Santiago is an expert in microfluidics—compact chemistry labs that are increasingly being used to test various liquids for toxins, pollution, parasites, microbes and more. Santiago is working to adapt one of his microfluidic tests for tuberculosis to detect the presence of the SARS-CoV-2 virus that causes COVID-19. Here's an excerpt of a conversation with him about his project.

What is microfluidics?

Microfluidics is, essentially, a tiny medical lab that fits in the palm of your hand. There are very small tubes and pumps and so forth that move fluids—like those from a nasal swab, a teardrop amount is all it takes—through a series of chemical reactions. There's a computer processor monitoring everything and a USB connection relays information to and from a computer. In fact, our test can be controlled in the field using a smartphone. It's very mobile. Very compact. And very fast.

What is the advantage of your system over existing tests?

The advantages are several. First, it's portable and could be used by any doctor, nurse or technician in the field at the point of care. Second, it's fast. Existing tests can take eight hours or longer and samples must be sent to a central facility. No such point-of-care assay currently exists for SARS-CoV-2.

Lastly, and perhaps most importantly, our test can detect an active COVID-19 infection—which is key to early detection and treatment. The current rapid assays are based on antibodies to the virus, not the virus itself. So, those tests can tell the caregiver that the person has had the infection. Ours will tell them whether the patient is currently infected—and, therefore, infectious. This is a big distinction in isolating people who can infect others.

How does your test work?

In technical terms, the lab first looks for traces of genetic material in the sample—a corollary to DNA known as RNA. RNA is the protein that decodes DNA to create the proteins necessary for life. Viruses leave little traces of themselves wherever they go in the form of RNA.

If you find RNA, you can actually recreate the DNA that produced it—a process known as reverse transcription. Next, we need to create a lot of the DNA, that is we need to "amplify" it. Then, we do another process where we tag the DNA from the virus with tiny fluorescent molecules, so that when we illuminate the sample with an ultraviolet light the samples with coronavirus glow green. That's how we would know the patient has the SARS-CoV-2 virus that causes COVID-19. In a sample where no virus RNA is present, the sample does not glow.

It's actually quite a bit more complicated than this, because a sample always contains lots of RNA—from the patient themselves, from any microbes present, even from other viruses that aren't life-threatening. We want to know specifically that the patient has SARS-CoV-2, and not the common cold or the flu. That's quite tricky as you can imagine, especially to do it fast enough to keep up with the virus.

All that transcribing, amplifying and tagging takes place in this compact package that can be taken into the field pretty much anywhere. We hope to get the test down to under 45 minutes or so, start to finish.

How quickly do you think you can have test kits ready to go?

Well, we think the window is too narrow to help out much with COVID-19, but we're working as fast as we can. However, a microfluidic test kit like this could be easily reconfigured to head off future epidemics much more quickly than with COVID-19. You could quickly email the new RNA you were looking for and the kits could be reconfigured on the spot to look for any new virus or microbe of concern. We use the tuberculosis bacterium in our test now—it's not safe to use the SARS-CoV-2 virus at this time—but the technology is applicable to any RNA, so you can imagine quick tests for bacteria like E. coli, MRSA, anthrax or viruses like the flu, Ebola or HIV, even parasites like malaria, schistosomiasis and others. It would be a very powerful tool.

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