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Moving the Needle: Georgia Tech Researchers Develop Portable "Vein Finder" for Faster, More Accurate Injections

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When medics are treating trauma patients, every second counts. Yet bruises, burns, and other physical conditions often make it difficult to locate veins and administer lifesaving drugs or solutions.

In response, a team of Georgia Institute of Technology researchers is developing an inexpensive, handheld device that uses Doppler ultrasound technology to find veins quickly.

"Depth and angle are the critical issues for vessel detection," says project leader Michael Gray, a research engineer at the Electro-Optical (EOSL) Systems Laboratory within the Georgia Tech Research Institute (GTRI). "Even if you locate a vein at the skin's surface, it's still easy to miss when you try to insert a needle into the tissue below."

The Doppler effect is a phenomenon that occurs when electromagnetic and sound waves interact with a moving object, altering wavelengths and frequency. For example, a police radar gun sends microwave signals to a moving car, and when signals bounce back, the change in their frequency provides a measurement used to determine the vehicle's speed.

Doppler ultrasound is similar, except that acoustical waves are transmitted. Compared to static skin and tissue, blood is a moving substance, so ultrasonic waves reflected from blood vessels have different characteristics than transmitted ones, providing critical 3-D information about a vein's location.

Hospitals have sophisticated ultrasound systems to evaluate the heart, valves and vessels for general blood-flow studies. But this kind of equipment is impractical and too costly for field use.

“Although the use of Doppler technology isn’t new, the novel aspect of our vein finder is the system’s design, which makes it both portable and economical,” says Peter Rogers, a professor in Georgia Tech’s School of Mechanical Engineering.

The patent-pending vein finder is composed of two parts: A reusable unit houses the electronics and signal processing components, while a disposable coupler box holds a reflector and needle guide. The needle guide is positioned parallel to the sound beam being transmitted by a transducer in the device’s reusable section.

As medics move the device along a patient’s arm or leg, the transducer emits a thin acoustical beam, about the size of pencil lead, into the reflector. Then the reflector directs the ultrasonic waves into the patient’s skin at a slight angle. The device can determine the direction of blood flow to distinguish arteries (which carry blood away from the heart) from veins (which carry blood to the heart). Once the device detects a vein, an alarm is triggered, and medics insert the needle.

The vein finder has proved highly effective in initial tests on phantom tissue, a model that simulates human tissue and blood vessels. Researchers have now begun adapting the device for human use.

Developing the user-friendly vein finder has been a deceptively complex task.

"One reason it’s so challenging is that we’re using very simple components to keep costs down,” notes Francois Guillot, a research engineer in the School of Mechanical Engineering.

Unlike large ultrasound systems used by hospitals for general blood-flow studies, the vein finder is targeting a very small area of the body. “That means the acoustical beam has to be smaller,” says Jim Larsen, a research engineer in EOSL. Another complication is that only a small amount of energy, about 1/10,000 of transmitted waves, scatters off the vein.

“So you’re limited in how much energy you can put in and how much you can pick up,” he adds. “Cost, size and power issues restrict us to using a single sensor, which limits the type of signal processing we can do to eliminate the scattering effects.”

Once the system is successfully adapted for humans, data processing and electronics will be miniaturized in a prototype for field-testing. The researchers envision the final product will be about the size of a fat fountain pen.

Compared to existing devices on the market that try to locate veins with lights or heat strips, the GTRI-developed system will be faster and more reliable, says Connell Reynolds, founder of Reynolds Medical Inc., a medical device manufacturer in Fairburn, Ga., that is sponsoring the project.

A former paramedic, Reynolds says the vein finder will be invaluable for a variety of medical users, including ambulance services, hospital emergency rooms, clinics, the military and nursing homes.

"For example, IV (intravenous) insertion is especially difficult in dehydrated patients because their blood vessels lack normal volume," he explains. "Similarly, because cardiac patients' hearts aren't pumping properly, their veins are hard to locate. It's also difficult to find veins in obese people and young children because their vessels are covered by layers of fat."

In addition to speed, the vein finder's accuracy will make treatment easier for hospital patients who need ongoing IVs or blood work.

Larsen recalls a hospital stay of his own that required numerous blood tests. This resulted in swelling and inflammation in his arms, making it increasingly more difficult for nurses to find his veins. "It often took seven or eight tries," he says. "It wasn't long before I felt like a pin cushion."

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