Listen to your heart: AI tool detects cardiac diseases that doctors often miss

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When your doctor listens to your heart through a stethoscope they're listening to the distinctive lub-dub sound made by the heart's valves as they open and close, and straining to detect the subtle squelches and murmurs made when valves leak, stick, or slip out of place.

However, the body is a noisy place, and it's easy for doctors to miss the telltale sound of valvular heart disease amidst the cacophony of surging blood, rumbling bellies, and whooshing breath.

AI is here to help. Instead of relying on fallible human ears, researchers at Stevens Institute of Technology have developed a new diagnostic tool to detect and classify valvular disorders based on a short burst of audio data.

The results, reported on the cover of the September 2023 issue of *IEEE Transactions on Biomedical Engineering*, are striking: in just a few seconds, the team's AI tool can detect valvular heart disease, or VHD, with 93% sensitivity and 98% specificity, meaning that far fewer VHD sufferers went undiagnosed and that there were very few false-positive results.

"Most cases of VHD are missed because of human error—so we brought in AI to help the human," explained Negar Ebadi, the principal investigator of the project and an associate professor of electrical and computer engineering.

"In the realm of health care, the limitations of standard stethoscope examinations are evident. It is imperative that we invest in advanced diagnostic tools to bridge this gap and ensure early detection and treatment for all patients," added Arash Shokouhmand, lead author of the paper who recently earned his doctorate at Stevens.

In fact, research shows that just 44% of VHD cases are found by a standard stethoscope examination, which means patients' conditions worsen significantly before their disease is finally detected and treated—and costs the health care system more than $42 billion a year.

The team took 10-second recordings using a contact microphone—essentially a microphone that detects sound vibrations directly from a patient's chest. That data was then fed into an AI model adapted from speech-processing algorithms ordinarily used to isolate voices when people crosstalk over one another.

"The difference is that instead of detecting individual voices, we're detecting the audio signatures of specific kinds of heart disease," said Shokouhmand. By teasing the audio signal apart, the team's neural network is able to quickly identify five different valvular diseases from a single data sample—even if multiple diseases co-exist in a single patient. Within seconds, the AI model spits out a simple five-digit string of ones and zeros: a zero for each negative result, and a one for each valvular disease that it detects.

"Our ability to detect multiple diseases simultaneously was a key innovation in this research," said Shokouhmand. "We aren't just showing that there's a valvular problem—we're able to identify the constellation of problems a patient is suffering from."

While researchers have previously used neural networks to detect VHD, the Stevens team is the first to use accelerometers instead of complex and cumbersome machines. Their method is also markedly more accurate and robust than previous AI-based diagnostic methods and has room for significant further development.

"Our current goal is to collect more data so we can begin to classify diseases by severity—so instead of showing that you have a particular valvular disorder, we could give a grade out of 10 describing how far the disease has progressed," said Ebadi.

The team also hopes to extend their method to detect other circulatory diseases, and eventually to bring their system into doctors' offices across the country to ensure that fewer cardiac disorders go undiagnosed.

More information: Arash Shokouhmand et al, Diagnosis of Coexisting Valvular Heart Diseases Using Image-to-Sequence Translation of Contact Microphone Recordings, *IEEE Transactions on Biomedical Engineering* (2023). DOI: 10.1109/TBME.2023.3253381

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