Automated AI algorithm uses routine imaging to predict cardiovascular risk

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Coronary artery calcification—the buildup of calcified plaque in the walls of the heart's arteries—is an important predictor of adverse cardiovascular events like heart attacks. Coronary calcium can be detected by computed tomography (CT) scans, but quantifying the amount of plaque requires radiological expertise, time and specialized equipment. In practice, even though chest CT scans are fairly common, calcium score CTs are not. Investigators from Brigham and Women's Hospital's Artificial Intelligence in Medicine (AIM) Program and the Massachusetts General Hospital's Cardiovascular Imaging Research Center (CIRC) teamed up to develop and evaluate a deep learning system that may help change this. The system automatically measures coronary artery calcium from CT scans to help physicians and patients make more informed decisions about cardiovascular prevention. The team validated the system using data from more than 20,000 individuals with promising results. Their findings are published in *Nature Communications*.

"Coronary artery calcium information could be available for almost every patient who gets a chest CT scan, but it isn't quantified simply because it takes too much time to do this for every patient," said corresponding author Hugo Aerts, Ph.D., director of the Artificial Intelligence in Medicine (AIM) Program at the Brigham and Harvard Medical School. "We've developed an algorithm that can identify high-risk individuals in an automated manner."

Working with colleagues, lead author Roman Zeleznik, MSc, a data scientist in AIM, developed the deep learning system described in the paper to automatically and accurately predict cardiovascular events by scoring coronary calcium. While the tool is currently only for research purposes, Zeleznik and co-authors have made it open source and freely available for anyone to use.

"In theory, the deep learning system does a lot of what a human would do to quantify calcium," said Zeleznik. "Our paper shows that it may be possible to do this in an automated fashion."

The team began by training the deep learning system on data from the Framingham Heart Study (FHS), a long-term asymptomatic community cohort study. Framingham participants received dedicated calcium scoring CT scans, which were manually scored by expert human readers and used to train the deep learning system. The deep learning system was then applied to three additional study cohorts, which included heavy smokers having lung cancer screening CT (NLST: National Lung Screening Trial), patients with stable chest pain having cardiac CT (PROMISE: the Prospective Multicenter Imaging Study for Evaluation of Chest Pain), and patients with acute chest pain having cardiac CT (ROMICAT-II: the Rule Out Myocardial Infarction using Computer Assisted Tomography trial). All told, the team validated the deep learning system in over 20,000 individuals.

Udo Hoffmann, MD, director of CIRC@MGH who is

the principal investigator of CT imaging in the FHS, PROMISE and ROMICAT, emphasized that one of the unique aspects of this study is the inclusion of three National Heart, Lung, and Blood Institute-funded high-quality image and outcome trials that strengthen the generalizability of these results to clinical settings.

The automated calcium scores from the deep learning system highly correlated with the manual calcium scores from human experts. The automated scores also independently predicted who would go on to have a major adverse cardiovascular event like a heart attack.

The coronary artery calcium score plays an important role in current guidelines for who should take a statin to prevent heart attacks. "This is an opportunity for us to get additional value from these chest CTs using AI," said co-author Michael Lu, MD, MPH, director of artificial intelligence at MGH's Cardiovascular Imaging Research Center. "The coronary artery calcium score can help patients and physicians make informed, personalized decisions about whether to take a statin. From a clinical perspective, our long-term goal is to implement this deep learning system in electronic health records, to automatically identify the patients at high risk."

More information: Roman Zeleznik et al, Deep convolutional neural networks to predict cardiovascular risk from computed tomography, *Nature Communications* (2021). DOI: 10.1038/s41467-021-20966-2