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AI-supported detection of cardiac abnormalities

Researchers at the Inselspital, Bern University Hospital and the University of Bern have developed an AI-based tool that detects and classifies abnormalities of the coronary arteries in CT images with high precision. This could significantly improve the diagnosis and treatment of rare heart diseases. The study demonstrates the concrete applications of AI in clinical practice and underlines the close collaboration in the field of digital medicine between the University of Bern and the Inselspital.

Anomalous Aortic Origin of a Coronary Artery (AAOCA) are very rare congenital heart defects that are often overlooked by the untrained eye, but can have serious health consequences. They can lead to sudden cardiac death or heart attacks, especially in young, physically active people. According to autopsy reports, up to 30 percent of unexpected deaths of young athletes can be attributed to coronary artery anomalies. As they occur very rarely and often poorly understood in terms of their clinical significance - whether benign or potentially risky - coronary anomalies can be difficult to identify and classify. Improved diagnostics that allow such anomalies to be detected fully automatically could be life-saving for patients.

A research team led by Prof. Christoph Gräni, Professor at the University of Bern and Director of Cardiac Imaging at the Department of Cardiology at Inselspital Bern, and Dr. Isaac Shiri, Head of Research for Artificial Intelligence (AI) in Cardiovascular Medicine at Inselspital, in collaboration with the University Hospital Zurich, has now developed an innovative, fully automated tool based on AI that detects and classifies AAOCA in cardiac CT images. The study was recently published in the journal Nature Communications.

Leading Bern center for coronary anomalies

"As one of the leading centers for the assessment of coronary anomalies, patients from all over the world are referred to our university hospital. We therefore had a large amount of data from cardiac CT images at our disposal, which we were able to use to train the algorithm," says Christoph Gräni, last author of the study. A total of 4,128 CCTA images from 2,376 patients were analyzed, 335 of whom are affected by AAOCA. The tool developed uses a two-stage deep learning algorithm for segmentation and classification. The first step, image segmentation, separates the relevant anatomical structures from the surrounding tissues to provide a clear view of the coronary arteries. After image segmentation, the classification step focuses on detecting AAOCA cases and determining where the anomalous coronary vessel originates from in the aorta. The model was validated with external datasets in collaboration with the University Hospital Zurich and also tested on a publicly

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Hochschulstrasse 6
3012 Bern
medien@unibe.ch

available dataset to ensure the robustness and reliability of the results.

High precision of the algorithm

"The AI-supported algorithm recognizes the cardiac malformations directly in the images and automatically determines the type of anomaly. The model showed a surprisingly high level of precision and was even able to identify borderline cases where even experts disagreed. This high accuracy underlines the potential of the tool to be seamlessly integrated into clinical workflows," explains Gräni. For example, the tool could provide real-time alerts for potentially high-risk AAOCA abnormalities and support imaging specialists in clinical diagnosis. The tool also enables large population-based image datasets to be searched specifically for coronary anomalies and their correlation with the clinical outcome to be analyzed. "Analyzing such rare diseases in large retrospective and prospective cohorts of images is too time-consuming manually, but precisely such studies are absolutely essential for improved risk stratification," says Gräni.

Close collaboration in the field of digital medicine

This work is an example of the direct impact digital medicine can have on improving patient care and the importance of close collaboration between the University of Bern and Inselspital in the development of AI applications in medicine. Advancing digitalization in medicine is a long-term strategic goal of the University of Bern's Faculty of Medicine and is closely aligned with the University of Bern's overarching digitalization strategy.

Further studies are needed to refine the model and test it in real clinical environments. Gräni's team is now developing a digital artificial twin for coronary anomalies together with the research group of Prof. Dr. Dominik Obrist from the Cardiovascular Engineering research group at the ARTORG Center for Biomedical Engineering Research. This requires important data from interventional measurements, which are collected in collaboration with Prof. Lorenz Räber, Head of the Heart Catheter Laboratory at Inselspital. This approach should help to assess the relevance of a coronary anomaly with the help of a digital and physical twin outside the patient - for example under simulated sports conditions - to avoid interventional examinations and better assess the risk. "This digital twin technology could be extended to other rare cardiovascular anomalies and transform cardiology diagnostics as a whole," concludes Gräni.

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Hochschulstrasse 6
3012 Bern
medien@unibe.ch

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Contact

Prof. Dr. med. Christoph Gräni
Head of Cardiology and Head of Cardiac Imaging, Department of Cardiology, Inselspital, Bern University Hospital, and University of Bern.
E-Mail: christoph.graeni@insel.ch
Tel: +41 31 63 2 45 08

Media Relations
Hochschulstrasse 6
3012 Bern
medien@unibe.ch