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Editorial

Enhancing Invasive Coronary Angiography by Integrating Artificial Intelligence

Yuan Zhi [1], Florim Cuculi [1,2] and Matthias Bossard [1,2,*]

[1] Cardiology Division, Heart Center, Luzerner Kantonsspital, 6004 Lucerne, Switzerland
[2] Department of Health Sciences and Medicine, University of Lucerne, 6005 Lucerne, Switzerland
* Correspondence: bossard.matthias@medportal.ca

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The recent rise of artificial intelligence (AI) has become unstoppable in cardiovascular medicine [1]. Its integration into data management and, increasingly, data interpretation has opened avenues that were unimaginable only a few years ago [1,2]. Consequently, both clinicians and industry show growing interest in using AI to support decision-making and ultimately improve patient management.

In this context, artificial intelligence-based quantitative coronary angiography (AI QCA) represents a compelling technological advancement in a field that has historically been prone to subjective interpretation—at times little better than reading tea leaves. It is important to recognize that the majority of therapeutic decisions during invasive coronary angiography are still based solely on visual assessment of radiographic images [2]. This means that, in some cases, deciding whether a coronary lesion requires PCI or even bypass surgery relies on what is essentially informed guesswork. Therefore, simple and reproducible technological solutions that support objective grading of coronary artery disease are especially welcome.

Historically, quantitative coronary angiography (QCA) emerged in the late 1970s and early 1980s as an effort to overcome the inherent subjectivity of visual angiographic assessment [3,4]. By applying geometric edge detection algorithms to digitized angiographic images, early QCA systems enabled objective measurement of lumen diameter, percent diameter stenosis, and late lumen loss [4]. Over subsequent decades, improvements in image resolution, calibration methods, and automated contour detection enhanced both accuracy and reproducibility, establishing QCA as a reference standard for clinical trials [5].

Today, with the integration of artificial intelligence and 3D reconstruction, QCA is evolving into a faster, more robust, and increasingly clinically applicable tool for guiding coronary intervention [5]. Real-time, fully automated quantitative analysis of coronary lesions has the potential to bypass time-consuming manual contouring and vessel border detection, enabling immediate, reproducible measurements directly in the catheterization laboratory. Recent studies have demonstrated impressive performance metrics, with AI QCA systems reliably identifying coronary lesions and providing accurate quantitative measurements that correlate strongly with manual QCA across key parameters, including diameter stenosis, minimum lumen diameter, and lesion length [5].

The FLASH Trial demonstrated that AI QCA-assisted PCI is noninferior to intracoronary imaging-guided PCI using optical coherence tomography (OCT) with respect to

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postprocedural outcomes [6]. These findings suggest that automated, AI-driven quantitative assessment can achieve results comparable to imaging-guided PCI, without the need for actual intracoronary imaging [6].

Despite the promising results, a fundamental challenge remains unresolved: domain shift. This phenomenon leads to performance degradation when models encounter images from different clinical settings with varied acquisition protocols, study populations, and equipment. The underlying causes are not limited to potential biological differences but also include variations in imaging protocols, device types, and clinical workflows.

This raises a critical question: Can AI QCA maintain its performance across diverse healthcare settings and populations? The study presented in this issue addresses this fundamental gap by providing external validation of an AI QCA system in a European cohort—an essential aspect of current research, yet still underrepresented, in AI-based cardiovascular imaging.

The cardiovascular imaging domain has vulnerabilities to this challenge. Most AI QCA development studies use datasets from limited geographic regions, often from single countries or healthcare systems [6]. While this study developed AI QCA in South Korea with Asian cohorts as the original dataset, it also performed external validation using multicenter datasets from Europe, particularly important given documented inter-ethnic differences in coronary vessel diameter and plaque composition between Asian and European populations [5]. Moreover, most studies have evaluated quantification based on a manually selected optical frame for investigating the performance of AI QCA. From a real-world perspective, it remains important to determine whether AI QCA can produce consistent and reliable results even when the optimal frame is not selected.

In practice, AI QCA streamlines the workflow of coronary angiography by eliminating time-consuming manual steps [5,6]. The automated system delivers real-time quantitative assessment of coronary stenosis without adding workload for the interventionalist, in contrast to manual QCA, which requires substantially more time. In this study, AI QCA showed strong agreement with manual QCA when using manually selected frames [5]. Even with fully automated frame selection, the system demonstrated high accuracy, achieving a lesion detection rate of 86.2%. In everyday clinical practice, there is rarely time for manual QCA, and visual estimation—despite years of experience—remains prone to error with potentially serious consequences [5]. Manual measurements typically require 3 to 5 min, including frame selection and detailed stenosis analysis, thereby prolonging the procedure. This time-intensive process can be effectively replaced by AI QCA.

Prior AI QCA studies have been limited by the absence of independent validation cohorts, lack of gold standard comparators, reliance on non-clinically meaningful stenosis thresholds, and training on small or homogeneous datasets [5]. This external validation in a European cohort is an important advance, but it also underscores a critical reality: acceptable performance metrics alone will not bring AI QCA into clinical practice, as summarized in Figure 1.



Figure 1. Does AI QCA travel well? External validation in a European cohort.

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