Editorial

Artificial Intelligence and Cardiac Imaging: We need to talk about this

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"Measure what is measurable, and make measurable what is not so."

Galileo Galilei (1564-1642)

With the rapid technological progress experienced by medical imaging in recent years, the conversion of digital images into high-dimensional data, that is, with a large number of variables, has been driven by the concept that images contain a myriad of underlying pathophysiological information that is often difficult identify and comprehend using conventional visual analysis.[1] The quantitative analysis of these images and the organization of these parameters in complex databases (Big Data) — with large volume, variety and speed of information generation — brought radiology closer to the new technological frontiers, involving Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL) (Figure 1).

"Images are more than pictures, they are data."[1] The mantra of modern radiology portrays the potential of this new understanding of imaging in the new age of precision medicine, going far beyond diagnosis and having a decisive role in clinical decision making. In this new and complex context, Cardiology has been a broad and fertile ground for AI approaches, as many heterogeneous and sufficiently prevailing diseases (ideal for large databases), such as heart failure and coronary artery disease, are yet to be sub-phenotyped in the constant pursuit of increasingly customized treatments. Besides, problems with acquisition time, high costs, efficiency and misdiagnosis are commonly observed and thus expected to be mitigated with the promising new applications of AI in cardiovascular propaedeutics.[2]

The first applications of AI in cardiac imaging were based on the automated quantitative measurement of anatomical parameters (such as stenosis and vascular dilatations) and functional parameters (such as ventricular ejection fraction) that were previously performed manually and were often considered laborious and time-consuming. The latest rapidly-evolving applications include the prediction of myocardial ischemia from automated coronary Fractional Flow Reserve (FFR) analysis using computed tomography (CT)[3] and identification of vulnerable plaques by CT angiography using radiomics, a tool of quantitative evaluation of images based on textural analysis, that is, heterogeneity of an area of interest from the distribution on pixels or gray levels of each voxel. Other recent applications include the development of automatic reconstruction algorithms, analysis of image quality with DL[5] and identification of incidental cardiovascular findings in CT and Magnetic Resonance Imaging (MRI) examinations. In addition to these axial methods, potential uses of AI tools in echocardiography are also comprehensive and include automated functional assessment (including ejection fraction and longitudinal strain), quantification of segmental contractility anomalies, and recognition of axes and structures with DL techniques.[6] Our group has been a pioneer in research on the subject in the country, developing studies that include textural analysis of coronary plaques and aortic valve by radiomics (Figure 2), prognostic markers in cardiomyopathies with ML[7] techniques and ventricular function evaluation with DL[8] tools.

Despite the encouraging results and the growing number of publications on the subject, there is still a long way to go before scientific evidence involving AI in cardiac imaging is implemented in clinical practice. The methodology of many of the latest studies differs significantly, and some of them have used mathematical corrections, which can lead to overly optimistic results — many without external validation. Another important point to be considered, when use AI to solve medical image problems, is the limited number of annotated data available for training. In most of the cases, this requires the involvement of well-trained physicians in a time consuming task, which limits the number of annotated data available. Other limitations include frequent variations of acquisition protocols (which may reduce data robustness), as well as the diversity of the methodologies used to extract features (quantitative information derived from images) and interpretation of the statistical models used. Consequently, more studies are needed to validate the potential of these techniques, preferably with larger samples, interinstitutional cooperation and consistent methodology and validation.

Notwithstanding the great enthusiasm of the scientific community, numerous doubts about the effects of all this great potential has generated excessive anxiety among professionals dealing with medical imaging. It is paramount to state that the use of AI tools in medical diagnosis is neither a threat nor a strategy to replace the role of the physician in the cardiovascular propaedeutics. By providing new diagnostic, predictive and prognostic data, with potential impact on the individualized therapy of these patients, such tools undoubtedly represent a potential strategy to increase the importance and precision of our work. We believe that AI has great chances of promoting optimization of workflow and support in the

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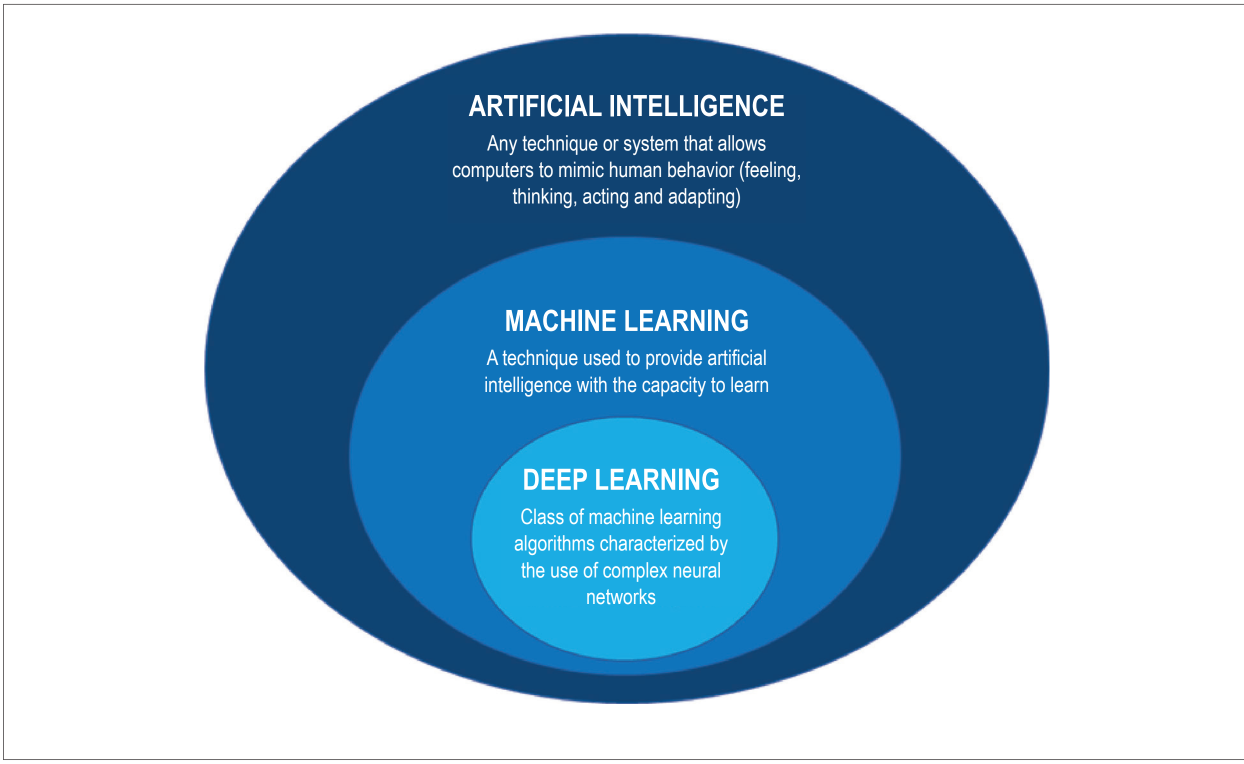

Figure 1 – *Diagram illustrating the basic concepts of artificial intelligence, machine learning and deep learning.*

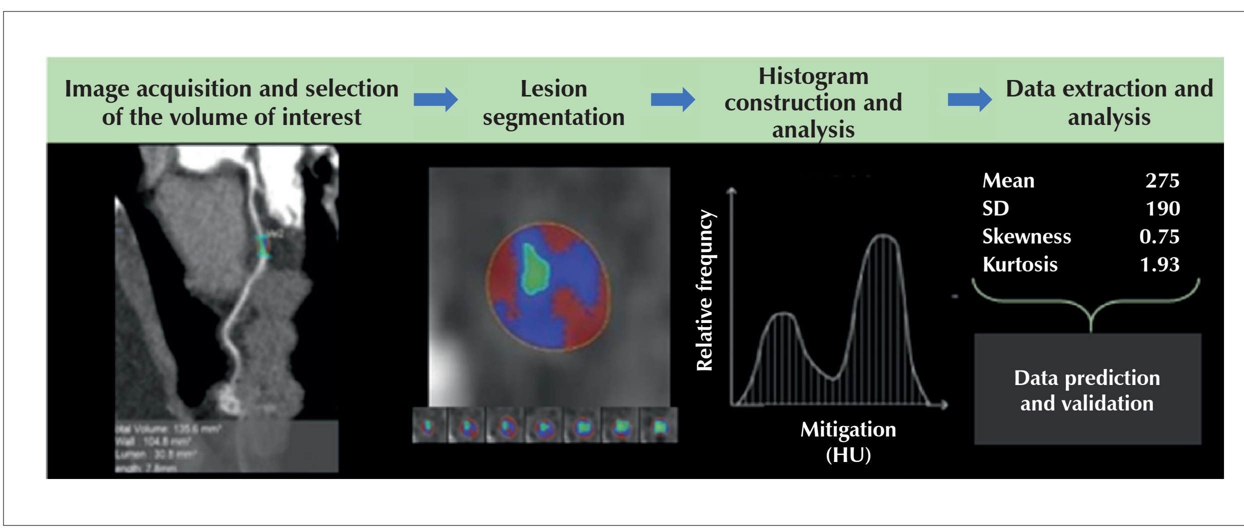

Figure 2 – *Workflow for characterization of coronary plaque using radiomics. First-order features were extracted from a heterogeneous plaque in the anterior descending artery.*

diagnosis in Radiology, as well as reducing the amount of stress and exhaustion among professionals and improving the quality of patient care.

Finally, we are sure that the incorporation of AI into cardiac imaging is not something to be feared or avoided, but discussed, understood and encouraged, both in multidisciplinary medical meetings and in the academic training of new professionals. We believe that all clinical and pathophysiological knowledge gained throughout our training and career will remain vital for the balanced use and interpretation of the new data generated by these tools.[9] It is up to us to take a leading role in deciding where and how to apply all this knowledge.

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