Preface: Artificial Intelligence and the Revolution of Oncological Imaging

In recent years, the intersection of artificial intelligence (AI) and medical imaging has emerged as a transformative force in the field of oncology. The integration of cutting-edge technologies, sophisticated algorithms, and vast datasets have paved the way for unprecedented advancements in the diagnosis, prognosis, and treatment of cancer. As the guest editors of this special issue, it is our distinct pleasure to present a comprehensive collection of contributions that delve into the realm of AI in oncological imaging.

Cancer, a complex and multifaceted disease, demands innovative approaches for early detection, precise characterization, and personalized therapeutic interventions. The combination of AI and oncological imaging holds immense promise for meeting these challenges. From the refinement of traditional imaging modalities to the exploration of novel techniques, the articles featured in this special issue showcase a diverse array of methodologies and applications that harness the power of AI to enhance our understanding and management of cancer.

Biomedical imaging has always been an area with a high technological vocation, and once again radiologists are at the frontier of innovation. The application of AI tools in medicine is not new, but in the past 5 years, we have witnessed an effective implementation of these tools in clinical routine, with a significant impact on patient management and workflow in radiology departments. The promising results that have been achieved using more traditional, statistics-based machine learning approaches are above all thanks to the development of deep learning models. This is a major paradigm shift, overcoming the traditional limitation of radiological assessment regarding the qualitative and discretionary component of the report, which is a source of variability and potential diagnostic errors, with impact on clinical choices and prognosis.

One of the main uses for AI in oncological imaging is in early detection and diagnosis. It will surely be useful in improving the sensitivity and specificity of early cancer detection, thereby facilitating timely interventions, and ultimately improving patient outcomes, which are the foundation of effective screening programs.

In the United States, first-read mammography screening is currently performed by an AI-based tool that identifies suspicious features so that only cases worthy of follow-up are submitted to the radiologist. This is enough to illustrate the scale of the revolution underway, and it illustrates two main points: (1) the diagnostic reliability of these tools that today allow us to entrust diagnostic tasks of fundamental importance for the patient, and (2) the impact that their implementation will have on radiology and the radiological profession, with occupational and medico-legal implications that must be taken into consideration by doctors and policymakers.

At the basis of this new frontier, there is also a new conception of the radiological image, which is no longer conceived as a simple figure, but rather as a set of numerical data providing valuable information. The availability of ever-increasing computing power and accurate deep neural networks trained on large, multicenter databases have made it possible to develop and validate extremely accurate diagnostic models. Many of these tools are already commercially available. Particularly in oncological imaging, the systematic and reproducible extraction of quantitative image characteristics and their correlation with clinical data allow for improved diagnostic assessment and accuracy in reporting, with a significant impact on clinical decisions. New possibilities also open up, such as the non-invasive identification of molecular features of neoplasms, which, although unlikely to be able to replace histological data, will support the latter in some phases of the diagnostic process, providing additional information during the first instance diagnosis or follow-up. The main areas of application of AI in the field of oncological imaging include accurate tumor segmentation, differential...
diagnosis, lesion characterization and grading, prediction of response to treatment, monitoring of therapeutic response, and prediction of prognosis, all of which will help to move us to the realm of precision medicine, where individualized treatment plans are tailored based on the unique characteristics of each patient’s tumor as revealed by imaging data.\textsuperscript{10}

As we navigate the complex landscape of AI and its transformative impact on oncology, this special issue serves as a platform to disseminate knowledge, foster interdisciplinary collaborations, and inspire future innovations. We hope that the insights shared within these pages will not only contribute to the academic discourse but will also catalyze advancements that ultimately translate into improved patient care.

The future will see radiology as an integral part of a multi-omics network, which includes other levels of analysis of each patient’s complexity, including genomics, proteomics, metabolomics, and, in the neuroradiological field, connectomics. In the near future, it is realistic to expect a further level of integration that will lead to the development of digital counterparts of patients (the so-called digital twins),\textsuperscript{11} which will allow us to simulate prevention plans, plan surgical interventions, and predict the effectiveness of treatments in an increasingly personalized manner that is specific to each patient.

The revolutionary scope of these innovations is accompanied by equally as many challenges for radiologists and clinicians,\textsuperscript{12} who are called to collaborate even more closely. First and foremost, developing effective AI tools require rigorous pipelines and robust validation protocols.\textsuperscript{13} AI is a broad field that receives contributions from other sciences (e.g., programming, statistics, and data mining), requiring the radiologist to build a minimum background in each of these disciplines to have a common lexicon with other professionals and effectively contribute to research and innovation. However, because these skills cannot under any circumstances be exhausted by a single radiologist, this reinforces the need for multidisciplinary collaboration. Finally, ethical considerations and legal issues arise, both from the perspective of the patient and the radiologist and the scope of responsibility of the radiologist; potential solutions for widespread adoption are therefore needed.\textsuperscript{14,15}

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REFERENCES


