

FROM DATA TO DECISIONS: THE ROLE OF SPATIAL HISTOLOGY IN PRECISION ONCOLOGY

Vieco-Martí I., El-Ouardi M., Granados-Aparici S.; Noguera R.

- Pathology Department, Medical School, University of Valencia
- INCLIVA, Valencia, Spain.
- Centro de Investigación Biomédica en Red de Cáncer, Instituto de Salud Carlos III, 28029, Madrid, Spain.

Precision oncology requires the integration of clinical, molecular and tissue-based information to better understand tumor heterogeneity and guide therapeutic decisions. Spatially resolved histological analysis, using histochemical and immunohistochemical markers, is a key technology enabling the quantitative analysis of tissue architecture and tumor microenvironment organization. Digital pathology links tissue morphology through digital microscopy analysis and radiomics, with molecular and clinical data in precision oncology. Importantly, the interpretation of digital histological data benefits not only from the expertise of pathologists but also from the specialized knowledge of histologists in tissue structure and processing. In particular, the accurate delineation of tumor and non-tumor regions and/or malignant cells niches and tissue components within tissue samples provides the spatial framework required for reliable computational analysis. This spatial definition allows more precise characterization of stromal cells and extracellular matrix components within the tumor microenvironment. These elements represent important determinants of tumor progression, invasion, and therapeutic response. By enabling accurate spatial annotation of tissue regions, histological expertise complements computational image analysis and improves the performance of artificial intelligence approaches in histopathological diagnosis, prognostic assessment, and therapeutic decision-making. We discuss how spatial histological analysis integrates experimental tumor models and patient-derived samples to support biological interpretation and clinical decision-making in precision oncology.

We will analyze digital analysis strategies, translational platforms, and emerging technologies including artificial intelligence, spatial omics, and three-dimensional tumor reconstruction. Together, these approaches highlight the importance of histology-guided spatial analysis as a key component of precision oncology while also facing key challenges related to data standardization and reproducibility.