Editorial, PET/CT.

OMICS and Nuclear Medicine.

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ABSTRACT:

Omics, in particular, Radiomics are complementary approaches that provide a very comprehensive, multi-layered view of a disease, particularly cancer. Combining genetic, molecular, and imaging data with machine learning enhances the diagnostic and prognostic capabilities of nuclear medicine, and hence advances the field of personalized treatment. Notably, a substantial amount of research has explored the utility of nuclear medicine Radiomics in the context of digestive system tumors. It is a very optimistic and promising field of research that maximizes the diagnostic and prognostic yield of existing images. This development is expected to accelerate-workflow and enhance the precision of diagnosis and decision support prediction capacity, thus establishing a link between nuclear medical imaging and personalized diagnosis and treatment. The clinical impact of the human genome includes improved diagnostics for rare and complex diseases, more targeted and personalized treatments, and the development of new therapies like gene therapy. This knowledge allows for better prediction of disease risk, development of new drugs. A deeper understanding of how genetic variations influence health and disease, ultimately revolutionizing medical practice. To translate Radiomics into clinical practice, higher publication standards and standardization of workflows are needed.

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INTRODUCION:

In recent decades, we have witnessed an explosive growth of diagnostic tools that have changed the face of modern medicine, and nuclear medicine is at the top of the list. Nuclear medicine omics data help explain the specific uptake patterns seen on molecular imaging scans, such as positron emission tomography (PET). By analyzing a tumor's genomics, physicians can understand the metabolic behavior that is being visualized on an FDG-PET scan.

Omics and Radiomics are complementary approaches that provide a comprehensive, multi-layered view of a disease, particularly cancer [(1)].

Omics in Nuclear Medicine:

Omics refers to the study of a set of biological molecules, such as the "genomics" of DNA or the "proteomics" of proteins [(2&3).] It provides a detailed, microscopic view of the biological and functional processes within a patient at the cellular and molecular levels, aiming to understand the disease at a molecular level. This molecular information can be correlated with imaging data to help understand the biological underpinnings of what is seen on a scan. correlating specific gene mutations with Radiomics features can help predict tumor subtypes or aggressiveness [(2&3).].

Radiomics in Nuclear Medicine

- Radiomics uses high-throughput, automated analysis to extract the quantitative features from
- medical images features that may be invisible to the human eye. In nuclear medicine, Radiomics can analyze functional data from PET or SPECT scans to: Improve diagnosis and disease characterization Assess tumor heterogeneity Predict and monitor treatment response Help with patient stratification.

- **Evolution:**

  As an evolution of nuclear medicine, Radiomics allows for a more quantitative and deeper analysis of the biological information provided by its traditional methods.

The synergistic relationship

Complementary data: Omics and Radiomics provide complementary information. Radiomics analyzes the physical characteristics from the images (5), while omics provides the underlying molecular information.

Integrated models: By combining Radiomics and omics data using AI and machine learning, researchers can build more robust and accurate clinical prediction models than either data type could alone [6&7].

Radio-genomics: This integrated approach, known as radio-genomics, aims to bridge the gap between both imaging and molecular data for a more precise understanding of diseases like cancer. The ultimate goal is to use this integrated data to improve patient stratification, prognosis, and treatment strategies in the era of personalized medicine.

- By combining genetic, molecular, and imaging data with machine learning, they enhance the diagnostic and prognostic capabilities of nuclear medicine and advance the field of personalized treatment.

Omics: refers to the comprehensive study of large sets of biological molecules, such as genes, proteins, or metabolites. Key omics fields include:

Genomics: Analyzes an organism's entire DNA sequence to find genetic variants linked to diseases.

Proteomics: Identifies and quantifies the proteins expressed by cells or tissues.

Transcriptomics: Studies the total set of RNA molecules that act as intermediaries between genes and proteins.

Metabolomics: Measures the complete set of small-molecule metabolites, which offers a real-time snapshot of cellular activity.

Radiomics in nuclear medicine

Radiomics: is the high-throughput extraction of hundreds of quantitative features from medical images. These features are calculated using sophisticated algorithms that reveal tumor characteristics and patterns such as shape, intensity, and texture that are often invisible to the naked eye [8]. In nuclear medicine, Radiomics is applied to images from modalities such as PET and single-photon emission computed tomography (SPECT). **Quantitative analysis:** Unlike qualitative or semi-quantitative visual interpretation, Radiomics produces objective, quantifiable data about a tumor's phenotype.

Non-invasive insight: It provides a non-invasive way to measure the tumor characteristics and heterogeneity across the entire tumor volume, which is an advantage over invasive and limited tissue biopsies.

Machine learning: The large amounts of data generated by radiomics are analyzed with machine learning to create predictive models that can forecast prognosis, treatment response, and molecular characteristics.

The relationship with nuclear medicine

Nuclear medicine is the bridge that links omics and Radiomics, creating the integrated field of **radio-genomics**. Radio-genomics seeks to find associations between the features extracted from nuclear medicine images (radiomics) and molecular-level data (omics) [9].

Nuclear medicine uniquely contributes to this integration in several ways:

Imaging molecular processes: Nuclear medicine's greatest strength is its ability to directly visualize the molecular and physiological processes of a disease in a living patient, providing in vivo biological data.

Connecting the microscopic and macroscopic: It serves as a link that connects the microscopic, genetic-level information from omics with the macroscopic, tissue-level information from radiomics.

Personalized treatment: Combining these two data sources from omics and the and from nuclear medicine imaging and radio-mics can significantly improve cancer diagnosis, staging, and treatment planning for individual patients.

A typical integrative workflow:

A common clinical application, such as personalized cancer treatment, illustrates how these fields work together:

Image acquisition: A nuclear medicine PET/CT or PET/MRI scan is performed after injecting a radiopharmaceutical tracer that targets specific biological activity, like glucose metabolism ([18F]-FDG).

Omics analysis: A biopsy is taken to perform genomic, transcriptomic, and proteomic analyses that provide detailed molecular information about the tumor.

Radiomics feature extraction: High-throughput algorithms are used to extract hundreds of quantitative features from the medical images, characterizing the tumor's shape, texture, and intensity.

Integration and modeling: The radiomic features, omics data, and other clinical information are combined into a multi-omic dataset. Machine learning algorithms then analyze this data to identify meaningful patterns and build predictive models.

Clinical application: The resulting models can be used for patient stratification, predicting treatment response, and assessing prognosis, helping to determine the most effective and personalized course of therapy.

The relationship with nuclear medicine:

Nuclear medicine is the bridge that links Omics and Radiomics, creating the integrated field of Radio-genomics, such associations between these features extracted from nuclear medicine images (Radiomics) and molecular-level data (Omics) [9].

Nuclear medicine uniquely contributes to this integration in several ways:

Nuclear medicine's greatest strength is its ability to directly visualize the molecular and physiological processes of a disease in a living patient, providing in vivo biological data [8 and 9]. Also, higher SUVmax (maximum standardized uptake value) is often correlated with the presence of KRAS mutations in certain cancers like colorectal and pancreatic, suggesting it can be a predictive imaging biomarker, but this relationship is not consistent across all cancer types and can be influenced by factors like tumor size. In some studies, particularly for lung cancer, no clear correlation was found, while in others, SUVmax was found to be a significant predictor of KRAS mutations, often in combination with other factors like metabolic tumor volume (MTV). Therefore, while SUVmax may be a useful supplemental tool, its predictive accuracy is limited on its own and requires further validation and integration with other clinical factors.

Furthermore, Higher SUVmax is associated with **KRAS** mutations in certain cancers like colorectal and pancreatic cancers. For example, in metastatic colorectal cancer, studies found that KRAS-mutated tumors had significantly higher SUVmax, especially when the tumor was larger than 10 mm **(fig. 1).**

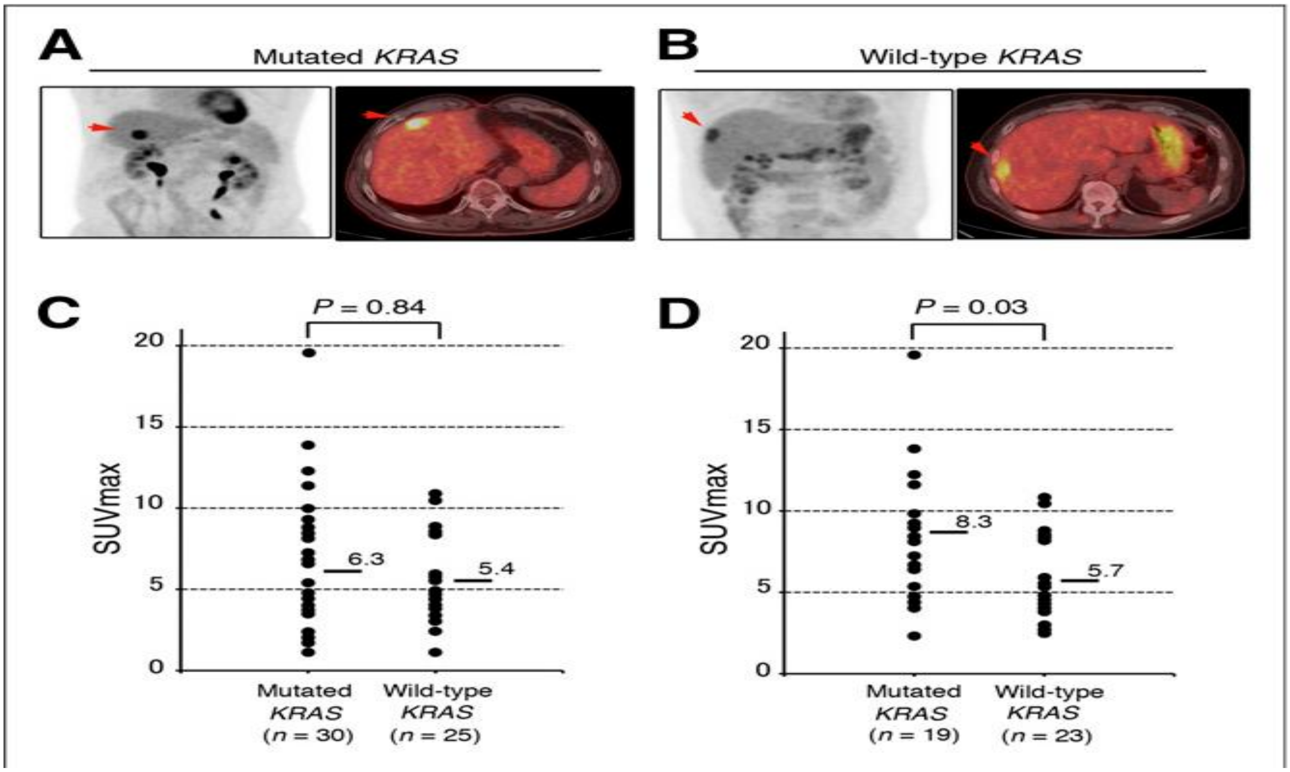

Fig. 1: Relationship between 18F-FDG PET/CT scans and KRAS mutations in Metastatic CRC; (KawadaK et al) [11].

However, no consistently predictive value between SUVmax and KRAS mutation status is not found in all cancer types. Some studies on non-small cell lung cancer (NSCLC) did not show a consistent trend, or no relationship at all. Also, SUVmax is often not sufficient for accurately predicting KRAS status. However, combining it with other metabolic parameters like MTV in predictive models has shown greater accuracy in predicting KRAS mutations. The relationship can be influenced by various factors, including the specific cancer type, tumor size, and the presence of other mutations. Small samples in some studies may contribute to inconsistent results [10]. Also, it serves as a link that connects the microscopic, genetic-level information from omics with the macroscopic, tissue-level information from Radiomics. Personalized treatment: Combining these two data sources from omics and from nuclear medicine imaging and Radiomics can significantly improve cancer diagnosis, staging, and treatment planning for individual patients [11].

A typical integrative workflow

A common clinical application, such as personalized cancer treatment, illustrates how these fields work together: A nuclear medicine PET/CT or PET/MRI scan is performed after injecting a radiopharmaceutical tracer that targets specific biological activity, like glucose metabolism ([18F]-FDG). A biopsy is taken to perform genomic, transcriptomic, and proteomic analyses that provide detailed molecular information about the tumor. Radiomics feature extraction: High-throughput algorithms are used to extract hundreds of quantitative features from the medical images, characterizing the tumor's shape, texture, and intensity. The Radiomics features, omics data, and other clinical information are combined into a multi-omic dataset. Machine learning algorithms then analyze this data to identify meaningful patterns and build predictive models. The resulting models can be used for patient stratification, predicting treatment response, and assessing prognosis, helping to determine the most effective and personalized course of therapy [(11)].

CONCLUSIONS:

Radiomics, whether handcrafted or deep, is an emerging field that translates medical images into quantitative data to give biological information and enable phenotypic profiling for diagnosis, thera-gnosis, decision support, and monitoring. However, a substantial amount of research has explored the utility of nuclear medicine Radiomics in the context of any system tumors. It is a very optimistic and promising field of research that maximizes the diagnostic and prognostic yield of existing images.

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