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Editor Letter / Carta ao Editor

Precision Imaging for Quantitative Analysis of Lung Neoplasms: State-of-the-Art

Imagiologia de Precisão para Avaliação Quantitativa de Neoplasias Pulmonares: Estado-da-Arte

José Raniery Ferreira Junior

Pesquisador SR do Instituto do Coração (InCor) do Hospital das Clínicas (HC-FMUSP) e Pesquisador Colaborador do Centro de Ciências da Imagem e Física Médica (CCIFM) da Faculdade de Medicina de Ribeirão Preto (FMRP-USP), ambos da Universidade de São Paulo (USP), Brasil

Correspondência

José Raniery Ferreira Junior
Av. Dr. Enéas Carvalho de Aguiar, 44, CEP 05403000, São Paulo, Brasil
email: jose.raniery@incor.usp.br

Abstract

Methods of computerized analysis have been developed for decades, despite having limitations, to increase diagnostic accuracy as they can precisely recognize patterns in medical examinations. One alternative that has shown promising results to the community is based on quantitative radiomics assessment. Radiomics is motivated by the premise that it can reveal the underlying phenotypes of diseases captured at a macroscopic level, providing a new representation to lesions, ultimately supporting personalized medicine. In this paper, radiomic tools are explored to support that premise, finally disclosing the advance of computer-based markers and clinical decision support models for precision health care.

Keywords

Radiology; Tomography; Artificial intelligence.

Resumo

Métodos de análise computorizada, apesar de possuírem limitações, têm sido desenvolvidos durante décadas para aumentar a acuidade diagnóstica pois podem reconhecer precisamente padrões em exames médicos. Uma alternativa que vem apresentando resultados promissores à comunidade é baseada em avaliação radiómica quantitativa. A radiómica é motivada pela premissa de poder revelar fenótipos de doenças capturadas a um nível macroscópico, o que proporciona um novo nível de representação a lesões, permitindo apoiar a medicina personalizada. Este artigo explora ferramentas radiómicas que apoiam esta premissa, justificando o avanço de marcadores quantitativos de precisão e modelos de suporte à decisão clínica.

Palavras-chave

Radiologia; Tomografia; Inteligência artificial.

Personalized medicine is going through a digital revolution nowadays, mainly with the inclusion of artificial intelligence (AI) in everyday life. Computer aided detection/diagnosis systems (CADe/CADx) have been developed since the 80s with AI techniques to assist specialists in the early identification of lesions, such as pulmonary nodules.[1,2] However, content-based retrieval techniques (CBIR) have been incorporated into CAD tools in order to increase their clinical applicability. CBIR systems can be very useful clinically because they can increase the certainty of the diagnostic hypothesis, using a model based on previous examples with an already known outcome.[3]

In this context, radiomics is described as an extension of CAD/CBIR that associates quantitative characteristics of imaging studies with pathological outcomes. Radiomic tools have the potential to increase the power of clinical decision, as they describe the shape and texture of the lesions in minimal details impossible to be humanly evaluated, using advanced computational and mathematical algorithms.[1] In view of recent advances in targeted therapies for personalized medicine, the need for a simple approach to precise analysis has become imperative and radiomics can provide that as a non-invasive, fast and low-cost tool.[2]

Several CAD models have been proposed in the literature. However, the most investigated application was for the identification of incidental pulmonary nodules. At first, the focus of the research was on CADe methods based on intrinsic characteristics of the images to detect nodules on chest radiographs. But recently, studies have been focused on malignant neoplasms in computed tomography (CT) and the development of models to support decision making regarding treatment, which could potentially improve the assessment of the patient's prognosis and of the disease progression. Most CAD models for CT are composed of the previous segmentation of the lesion in the image and of the calculation of quantitative characteristics.[2,3] Traditionally, these characteristics belong to four major levels/orders of the image: (I) first order, which characterize the distribution of gray levels in the image histogram; (II) second order, which describe the spatial relationships of voxels in gray level matrices; (III) highest order, which characterize the lesion spectrum in the domain of the image frequency; and (IV) shape, which describe the size and geometric components of the lesion border. Other authors have proposed the development of automated AI models (i.e., deep learning), where neural networks perform the representation of the lesion (characterization of gray levels) and the radiomic association with the outcome even without the need for previous image segmentation, which further increases the relevance of the method.[4]

Other radiomic investigations have been presented in the literature associating characteristics of lung neoplasm on CT with several clinical outcomes: survival, histology, staging, genomics, recurrence, among others.[2,4,5] For instance, Ferreira-Junior et al.[2] presented radiomic features of CT with contrast of diagnostic and prognostic value associated with pathological patterns of non-small cell lung cancer (second-order directionality and the estimate of the highest-order fractal dimension) and with distant and ganglionic metastases (energy of the highest order and measure of correlation information of the second order).

Radiomics is currently being used to quantify intratumoral heterogeneity, which is the presence of multiple subregions (e.g., histological) in the same primary lesion, which can increase disease progression and therapeutic resistance. Radiomics is able to quantify the complexity of the tumor and identify heterogeneous subregions in the image, as shown in Figure 1. Ferreira-Junior et al.[1] identified a radiomic signature of the highest order at CT that stratifies the patient's risk of death and quantifies the intratumoral heterogeneity of lung malignant neoplasms. Beig et al.[5] investigated other characteristics of the highest order capable of identifying different intra and peritumoral regions expressed in adenocarcinomas and granulomas.

Radiomics, CBIR and CAD techniques have grown promisingly in the development of image markers and predictive models, increasing diagnostic accuracy, prognostic evaluation and assisting the therapeutic decision for personalized medicine. Future directions for the area include the identification of specific regions of resistance to treatment, allowing, this way, therapies located at a low molecular level.

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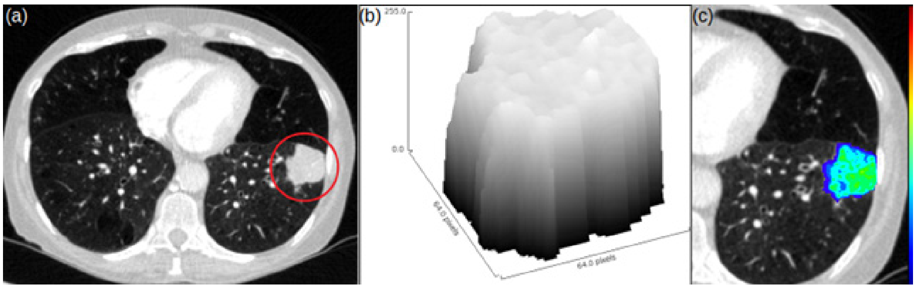

Figure 1 – Quantification of intratumoral heterogeneity in a non-small cell lung cancer: (a) CT image of the chest in the axial plane with a primary lesion (circle) of malignant neoplasm, (b) three-dimensional distribution of the segmented image's gray levels, (c) local energy map reflecting subregions in lung injury.r.

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