La candidata Francesca Laganaro estrae le domande n. 3:

PROVA TECNICA

1) La radiomica è uno strumento emergente di analisi quantitativa delle immagini biomediche, che consente di esplorare le potenzialità dell'informazione contenuta nelle immagini e di integrarla con variabili cliniche e biologiche. Il candidato descriva un esempio di applicazione in ambito oncologico.

2) Le potenzialità dell'intelligenza artificiale nell'oncologia di precisione sono molteplici, può infatti supportare la delineazione dei volumi bersaglio, l'elaborazione automatica di piani di trattamento radioterapici o la definizione di modelli predittivi e prognostici basati su dati multifattoriali. Il candidato descriva un esempio di applicazione in ambito oncologico.

3) La ricerca oncologica nell'ambito dell'imaging quantitativo può avere un ruolo importante nel promuovere gli avanzamenti tecnologici oggi disponibili, sia strumentali che computazionali, allo scopo di migliorare l'accuratezza diagnostica e l'efficacia delle terapie. In quali ambiti il candidato ritiene di poter dare maggiormente un contributo e con quali competenze già acquisite?

PROVA INFORMATICA

1) Cos'è un Database

2) Differenza tra hardware e software

3) Illustrare le principali applicazioni del pacchetto Microsoft Office

Istituti Fisioterapici Ospitalieri - ROMA

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REVIEW ARTICLE

Quantitative radiomics studies for tissue characterization: a review of technology and methodological procedures

[1]RUBEN T H M LARUE, MSc, [2]GILLES DEFRAENE, MSc, [1]DIRK DE RUYSSCHER, MD, PhD, [1]PHILIPPE LAMBIN, MD, PhD and [1]WOUTER VAN ELMPT, PhD

[1]Department of Radiation Oncology (MAASTRO), GROW—School for Oncology and Developmental Biology, Maastricht University Medical Centre, Maastricht, Netherlands
[2]Department of Oncology, Experimental Radiation Oncology, University of Leuven, Leuven, Belgium

Address correspondence to: Mr Ruben T H M Larue
E-mail: *ruben.larue@maastro.nl*

The authors Ruben THM Larue and Gilles Defraene contributed equally to the study.

ABSTRACT

Quantitative analysis of tumour characteristics based on medical imaging is an emerging field of research. In recent years, quantitative imaging features derived from CT, positron emission tomography and MR scans were shown to be of added value in the prediction of outcome parameters in oncology, in what is called the radiomics field. However, results might be difficult to compare owing to a lack of standardized methodologies to conduct quantitative image analyses. In this review, we aim to present an overview of the current challenges, technical routines and protocols that are involved in quantitative imaging studies. The first issue that should be overcome is the dependency of several features on the scan acquisition and image reconstruction parameters. Adopting consistent methods in the subsequent target segmentation step is evenly crucial. To further establish robust quantitative image analyses, standardization or at least calibration of imaging features based on different feature extraction settings is required, especially for texture- and filter-based features. Several open-source and commercial software packages to perform feature extraction are currently available, all with slightly different functionalities, which makes benchmarking quite challenging. The number of imaging features calculated is typically larger than the number of patients studied, which emphasizes the importance of proper feature selection and prediction model-building routines to prevent overfitting. Even though many of these challenges still need to be addressed before quantitative imaging can be brought into daily clinical practice, radiomics is expected to be a critical component for the integration of image-derived information to personalize treatment in the future.

1

INTRODUCTION

The use of quantitative imaging has been an attractive field of research to overcome the subjectivity of visual interpretation. However, in all imaging divisions from radiology to nuclear medicine, the amount of quantification is still limited and the majority of clinical decision-making is based on visual assessment. A common quantification is performed by the response evaluation criteria in solid tumours[1] that is based on the measurement of tumour size and frequently used for response assessment in oncology, whereas PET Response Criteria in Solid Tumours[2] is making its introduction in the nuclear medicine arena to allow simple quantification of maximum uptake of a tracer [*e.g.* maximum standardized uptake value (SUV) or SUV peak].

2 Besides these simple quantification methods, diagnosis is also complemented visually by the appearance of lesions having different properties or patterns that are used to differentiate between benign and malignant lesions. These appearances (*i.e.* imaging features) are typically described visually and the radiologist interprets and selects suspected lesions for future clinical investigations (*e.g.* biopsy). For many years, researchers have investigated computer-aided diagnosis techniques to automatize the workflow and improve accuracy.[3–5]

2

Nowadays, there is renewed interest in the combination of both quantification and visual assessment to provide a comprehensive quantification of imaging data sets. Instead of reporting only a single quantitative measure or a visual subjective report, image-processing techniques are available to describe many different properties that could be quantified from imaging such as the shape and size of tumours and intensity-based and textural properties with

or without additional filtering in a quantitative way. To overcome the wealth of parameters and information, these derived values are combined with statistical modelling techniques to predict a certain clinical end point (*e.g.* survival, local relapse); this field of research is now commonly called radiomics.[6]

The radiomics workflow starts with image acquisition. After image reconstruction, a region of interest is selected that defines the volume for feature extraction. Calculation of these features is performed by image-processing software sometimes including different pre- and post-processing steps. Next, a statistical model is built that allows the selection of features that are able to predict the outcome parameter (*e.g.* survival). Finally, a validation of the model needs to be performed, preferably external validation. An example of the workflow is shown in Figure 1. With this review, we aim to give an overview of the various technical routines and protocols that are involved in quantitative imaging studies such as radiomics. The influence and technical aspects of the above steps will be described in detail in the next sections.

IMAGE ACQUISITION

Medical images acquired for standard clinical diagnostics, (radiotherapy) treatment planning and follow-up purposes are a source of information for radiomics analyses. In the field of oncology, the most widely used modalities include ultrasound, CT, positron emission tomography (PET) and MRI. Many radiomics studies are relying on retrospective data sets, in which individual image acquisition parameters can be different. These different settings can have an influence on the quality and reliability of the extracted radiomic features, as will be discussed below in detail for the commonly used imaging modalities.

CT

Several groups investigated the repeatability and robustness of radiomic features in CT scans, showing that the features can have a high test–retest stability[7] with an acceptable dynamic range.[8] Mackin et al[9] scanned a phantom with different parameters on CT scanners of four different manufacturers. They found that variability in textural features calculated on CT scans from different scanners can be in the same order of magnitude as the variability observed in CT scans from patients with non-small-cell lung cancer (NSCLC). Zhao et al[10] used the publically available Reference Image Database to Evaluate Therapy Response data set,[11] consisting of 31 patients with NSCLC with same-day repeated CT scans, to assess the impact of slice thickness and reconstruction algorithm on the stability of 89 radiomic features. They concluded that repeatability of features derived from scans with the same imaging settings was good; however, only 19% of the features were repeatable when different settings were used. In cone-beam CT scans, Fave et al[12] found that radiomic features may be reliable as long as the imaging protocol is consistent and relative differences are used. In addition to all imaging parameters that should be taken into account before performing radiomics analyses, the influence of respiratory motion on radiomic features should not be underestimated. It was shown that up to almost 75% of the CT radiomic features can be susceptible to respiration, making breath-hold or four-dimensional CT acquisition necessary for moving lesions.[13]

Positron emission tomography

PET scans were used to show a good test–retest stability in up to 71% of the radiomic features in a cohort of patients with NSCLC.[14] In oesophageal cancer, heterogeneity parameters such as entropy, homogeneity, dissimilarity (local characterization) and variability in the size and intensity of homogeneous tumour areas (regional characterization) also had a good reproducibility.[15] However, various studies found that PET radiomic features can be susceptible to reconstruction parameters. For instance, Galavis et al[16] showed that in a cohort of 20 patients with different types of solid tumours, 40 (80%) of the 50 features tested presented large variations (range >30%) when the number of iterations, grid size, reconstruction algorithm and/or post-reconstruction filter was changed. This was also confirmed by van Velden et al[17] and Yan et al,[18] who tested the impact of the same reconstruction parameters on feature robustness. Respiratory motion causing blurring is another matter of concern. Yip et al[19] demonstrated that textural features can vary up to 19% when comparing their values derived from

Figure 1. An overview of the radiomics workflow and corresponding topics addressed in this review. PET, positron emission tomography.