Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Clinical Imaging 77 (2021) 299–300

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: www.elsevier.com/locate/clinimag

Editorial

The need for standards for COVID-19 quantitative imaging analysis applications

ARTICLE INFO

Keywords
Quantitative imaging analysis
COVID-19
Standardization
Open science research databases

The first attempts in using quantitative analysis of medical images can be traced back to the early 1960s with the development of computer-aided diagnosis (CAD), with which researchers found ways to aid in clinical diagnosis using statistical analysis and probability theories.[1] Fast forward 60 years to the era of radiomics, in which advanced machine learning techniques are allowing us to find correlations between quantifiable imaging characteristics and the underlying biology of diseases.[1] We have jumped from using tools that help radiologists automatically identify normal and abnormal structures on images (e.g., lung nodules or breast microcalcifications in the setting of cancer screening) to the hope that software tools will provide information on the nature of these abnormalities (e.g., benign vs malignant) and will predict clinical outcomes. Some of these tools will rely on features the radiologist can visually confirm, but others will create new features (deep learning).

Quantitative image analysis (QIA) has been increasingly used for oncologic diseases, but research in non-oncologic settings is growing fast. The latest new promising application for QIA is COVID-19. In Wuhan, China where the COVID-19 pandemic originated, CT was quickly adopted by many as an early diagnostic test. However, since then, the use of CT for early diagnosis of COVID-19 has been controversial. The American College of Radiology, citing lack of specificity, does not recommend using CT for screening or as a first line diagnostic test for COVID-19, reserving its use for hospitalized symptomatic patients with specific clinical indications.[2] In favor of its use are the immediate availability of the results and the high rates of abnormalities on CT even in asymptomatic individuals.[3] Notable examples include the report from the Diamond Princess cruise ship. The ship docked in Yokohama for quarantine with 3711 passengers on board after transferring one ill passenger to shore who was later confirmed to have COVID-19 by RT-PCR.[4] Over the subsequent weeks which followed, close to 20% of the passengers and crew tested positive, and almost half of them remained asymptomatic. However, lung opacities were found in 54% of asymptomatic individuals with positive RT-PCR who underwent CT.[3] In another study, a meta-analysis found abnormalities on CT with ground glass opacities (GGO) as the predominant finding in 60% of asymptomatic patients with SARS-CoV2 infection.[5] These and other studies suggest that CT could be useful not only for diagnosis in symptomatic cases, but also to screen for asymptomatic individuals at risk for spreading the disease. Although RT-PCR results can be obtained fairly soon, the reality is that in many places it can take up to 48 h or longer. In contrast, the results of a CT of the chest are available immediately and the time it takes for its interpretation will be the limiting factor. Here is where QIA may play a role. Other limiting factors to consider for high output settings in the context of great demand due to a high incidence rate as was seen during the peaks of the pandemic, are disinfection of the CT suite and equipment, as well circulation of potentially infectious patients through hospital corridors. If a CT scanner is to be used for screening asymptomatic individuals, then careful measures to avoid spreading of the disease in the CT suite or via the CT equipment should be implemented.

Although promising, automated image quantification and analysis has resulted in contradictory results. One example is what occurs in the determination of emphysema on low-dose CT (LDCT) in the context of lung cancer screening. In 2006, de Torres *el al.* showed that in a lung cancer screening cohort, the presence of emphysema on the LDCT was independently associated with a 2.5-fold greater risk of having lung cancer.[6] In this study, LDCT images were analyzed visually to determine the presence or absence of emphysema. Subsequent studies using the same visual approach confirmed these findings.[7–9] On the other hand, several other studies in which emphysema was quantified using software tools failed to find the correlation between lung cancer risk and emphysema.[8] However, Labaki et al. did find recently that automated quantification of emphysema measured on noise-filtered LDCT using a cutoff of −950 HU is associated with lung cancer incidence and mortality.[10] Why only one of many studies using automated quantification of emphysema has reproduced results found with visual qualitative assessment is not clear. Differences in image acquisition protocols and lack of standardization of CT devices may be a reason, but differences in what the radiologist and the software see could also be important.

In this issue of *Clinical Imaging*, AUTHOR et al. have developed a guidance document for the Radiologic Society of North America (RSNA) Quantitative Imaging Biomarkers Alliance (QIBA) that focuses on developing a CT scanning protocol with a view towards development of high-quality quantitative imaging algorithms and advanced image

https://doi.org/10.1016/j.clinimag.2021.05.010
Received 30 April 2021; Accepted 6 May 2021
Available online 19 May 2021

processing tools.[11] What is particularly notable is that this guidance document brings together groups representing industry, government and academia, including two major existing QIBA groups (CT Small Lung Nodule Profile Committee and CT Lung Density Profile Committee) to establish imaging standards including choice of reconstruction kernels and image acquisition settings. Global partners also participated in developing this document from North America, Europe and Asia so that we now have image guidance that will set a standard for the global community in its fight against a global pandemic.

Although any new AI-based technology is promising, not all new technologies are necessarily better. Referring to COVID-related lung abnormalities, AUTHOR et al. claim that radiologists can only provide gross estimates of the extension of the disease. However, we have been treating patients with acute and chronic problems with these "gross estimates" for decades. Perhaps that is all that is needed for clinical purposes. Intuitively, the idea of obtaining information on the pulmonary vasculature, or the ability to detect subtle changes in serial CTs, sounds very attractive. Will finding abnormalities not obvious to the human eye that may portend a worse prognosis or may detect disease in an apparent normal image be useful in the fight against COVID-19? In would appear that it should, but we do not yet have the answers. As the authors correctly state, it "will depend on the quality and consistency of the CT imaging data in conjunction with curation of accurate information on patient presentation, timing of disease progression, and patient outcome". Furthermore, the article proposes "best practice methods and CT image acquisition parameters to support optimal ongoing and future quantitative analysis of COVID-19". This is potentially extremely impactful.

Research in numerous aspects of the COVID-19, especially in the field of vaccine development, is occurring at previously never seen high speeds, mainly due to the unfortunate extremely high numbers of patients worldwide, but also due to the willingness to establish generous collaborations among centers from different cities and countries. In this regard, to advance in the knowledge of quantitative imaging analysis for COVID-19, AUTHOR et al. underline the importance of contributing COVID-19 CT imaging datasets to open science research databases. The key will be to standardize protocols and to create large datasets to conduct quick clinical research studies. Only by doing this is there any chance of obtaining such spectacular results as we have witnessed in other COVID-19 related fields.

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