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The advent, value and place of quantitative imaging

Quantitative imaging is the future: that is the expectation of Dr. Firdaus Mohamed Hoesein, chest radiologist at UMC Utrecht, who explains why: 'It is difficult for radiologists to assess the percentage of affected lung precisely on a pulmonary scan. There is a clear need to ascertain precisely how much lung tissue is affected and be able to express it as a number. This way we can also measure and monitor disease progression and treatment outcomes over time.'

Quantitative imaging uses a computer algorithm to indicate numerically how much disease activity there is. 'That is a major gain compared to the way we radiologists currently operate', thinks Mohamed Hoesein.

QUALITATIVE VERSUS QUANTITATIVE

At present, scans are assessed visually, i.e. qualitatively, which makes it difficult to determine the quantity, i.e. the extent of the disease. 'We look at a scan and say, for example, there is a little bit of emphysema', as the Utrecht radiologist describes the current approach. 'Also, radiologists are unable to detect some subtle abnormalities that a computer can detect. And how those abnormalities are classified can differ from one radiologist to another. One problem is that, when a fellow radiologist looks at the same scan, it is difficult to compare the results if we only consider qualitative measures, and that is true of follow-ups too. It is difficult for a human to detect a minor increase in emphysema, there is no yardstick for that.' There is therefore a need for measurement, in addition to the work of the radiologist.

FIRDAUS MOHAMED HOESEIN

Firdaus Mohamed Hoesein studied medicine at Utrecht University the Netherlands. After obtaining his medical degree he performed research at the Department of Respiratory Medicine at the University Medical Center Utrecht (UMCU) in the Netherlands focussing on the role of quantitative CT imaging of the lungs. This resulted in a PhD in Respiratory Medicine in 2012. Dr. Mohamed Hoesein did a Radiology residency at the Department of Radiology of the UMCU and is a board-certified radiologist since 2017. He did a 1-year fellow-ship in thoracic imaging and has been working as a consultant thoracic radiologist at the UMCU since 2018. Dr. Mohamed Hoesein received several awards for his research on quantitative imaging in lung disease.

Quantitative imaging, e.g. Functional Respiratory Imaging (FRI, see www.fluidda.com) is able to show various aspects of airway problems, such as airway resistance, air trapping and ventilation mapping.

COMPREHENSIVE MEASUREMENT VERSUS LOCAL DISEASE ACTIVITY

A limitation of the lung function test is that it gives a value for the lung as a whole. The first limitation of spirometry that Mohamed Hoesein points out is that 'it is not clear where the problem lies, in the left or right lung, the upper or lower lobe'. 'On the CT scan you can see where the problem lies, for example in the left lower lobe, or conversely spread equally over the lobes. Another problem with the lung function test is that the results depend on whether patients do their best.'

If only a small proportion of the lungs is affected and the other parts are still functioning normally, a lung function test will often not detect the disease activity, as the lung function is still normal on average. 'In cases of COPD, for instance, we know that patients can have air trapping, emphysema and airway wall disease while their FEV1 is still normal. We can see those abnormalities on a CT scan. Quantitative imaging is definitely useful if the abnormality is not clear visually and the lung function is still normal.' Mohamed Hoesein consequently expects that quantitative imaging will be able to play a role especially during early disease stages and in prognosis.

MOHAMED HOESEIN'S RESEARCH INTO COPD AND COVID-19

Clinical drug trials often look at the effects on lung function, but if that improves only slightly, it is difficult to show major differences. The abnormalities will differ significantly on the scan, however, says Mohamed Hoesein. 'If we can measure that, it will benefit drug research.'

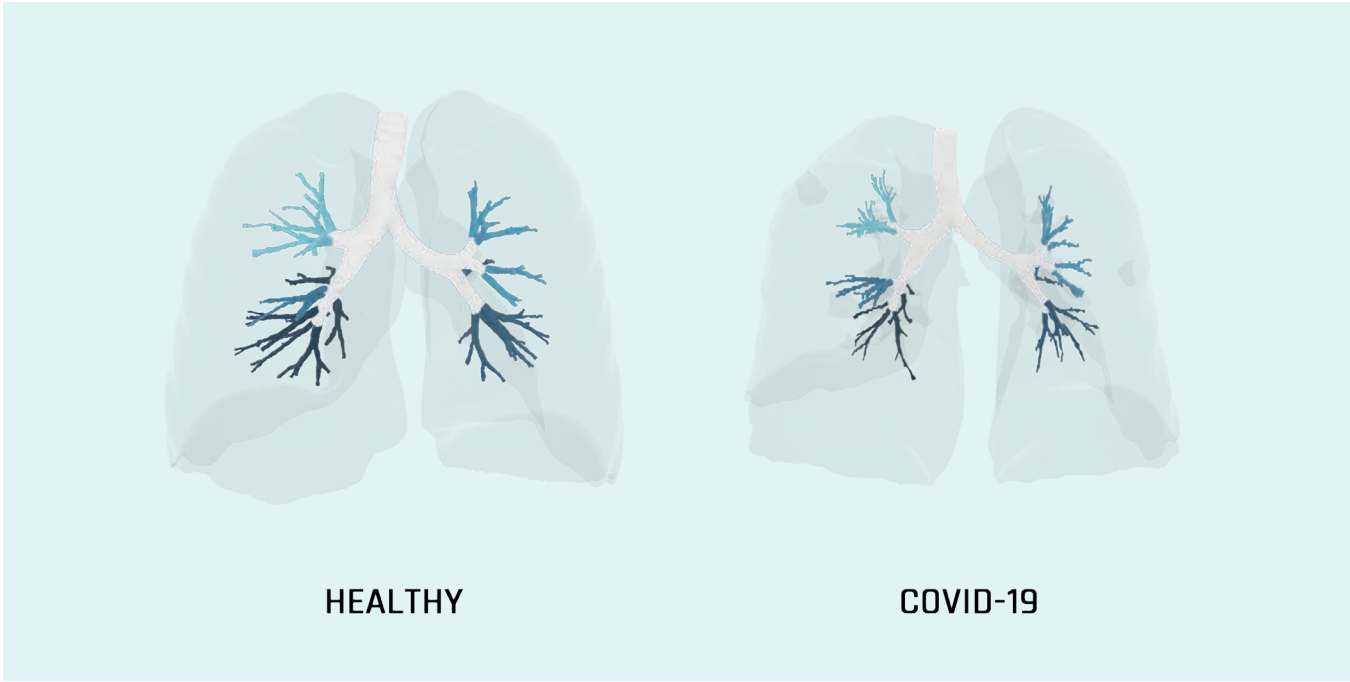
In their own research into quantitative imaging, Mohamed Hoesein and his colleagues found that some people with normal lung function already had emphysema. Lung function deteriorated more rapidly in patients already showing emphysema than in those with no emphysema and the same lung function. Over a longer follow-up period the dimensions on the CT scan have been found to be predictive.

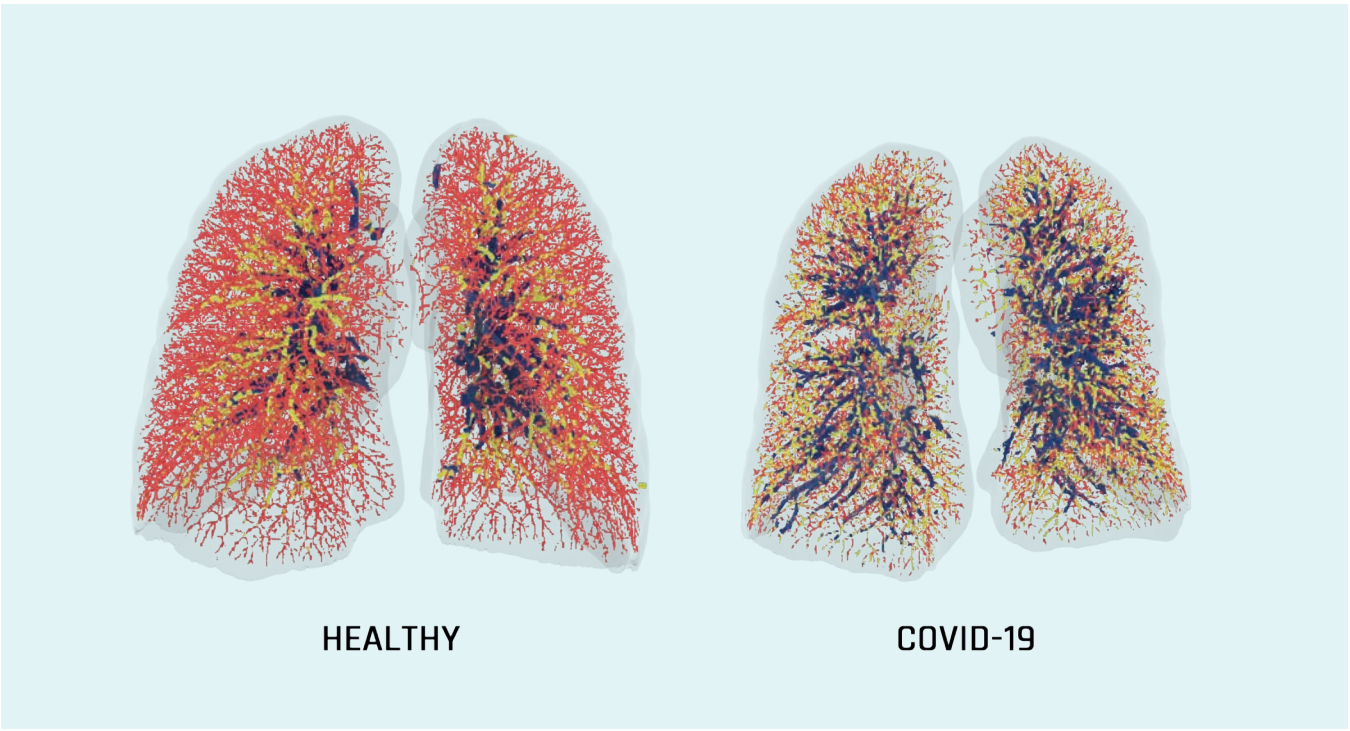
There is a good deal of interest currently in the radiological abnormalities found in COVID-19 patients. The long-term effects of COVID-19 in patients who have been admitted to hospital with that infection are being surveyed in a nationwide research program, known as Precision Medicine for more Oxygen (P4O2).[1] Mohamed Hoesein is the program's Principal Investigator responsible for the Imaging part of the program. 'We are using FRI to predict at an early stage which patients will deteriorate rapidly and who will have residual damage.'

The researchers are looking at the role played by the pulmonary blood vessels in COVID-19 patients, for instance. 'It would be interesting to find out whether the lung vasculature is different in patients with residual damage', notes Mohamed Hoesein. 'The blood vessel volume can be ascertained using FRI. The idea is that the blood vessel volume will be different in patients with severe COVID-19.'[2]

CHRONIC ILLNESSES IN PARTICULAR

In Mohamed Hoesein's opinion, quantitative imaging is useful in all lung diseases, but it could play a major role particularly in the long-term follow-up of patients with a chronic illness such as COPD, bronchiolitis obliterans, cystic fibrosis (CF), chronic respiratory tract infections or patients who have previously had a lung transplant. 'It is important to identify the long-term effects. Quantitative imaging could also play a role in patients who cannot do a lung function test, for instance because of COVID-19, as the





> A limitation of the lung function test is that it gives a value for the lung as a whole.

test entails an increased risk of transmitting SARS-CoV-2. In those cases we can do a CT scan.'

Quantitative imaging has added value in patients with CF, as their lung function has already deteriorated a priori. An improvement of only a few percent in a patient with poor lung function is difficult to measure using a normal CT scan. 'Those patients may be recovering well clinically, despite having substantial abnormalities on the scan', says the Utrecht radiologist. 'If we can identify those abnormalities on the scan, we can measure the disease activity better than with a lung function test.'

TRULY PERSONALIZED MEDICINE

We are living in a period of personalized health care technology, such as smart watches that can analyze heart rhythms in real time. In the future, Mohamed Hoesein expects that patients will want to receive the data from their CT scans. 'They will then have a value that tells them what their lungs are like, in other words what proportion of the lungs is functioning properly and what proportion is affected. The CT scan provides a snapshot of the lungs at that time, in other words truly personalized medicine. We will want to have it quantified, although that will take a while yet.' Currently, respiratory physicians check lung function every six months, for example, and plot any decrease or increase on a graph. The time will come when we can do that with these CT values, with patients being monitored over time. 'We can act quickly if there is any acute deterioration.'

EXPECTED PLACE

In the short term, Mohamed Hoesein expects that quantitative imaging will have a place mainly in clinical research, but in the long term, it may also have a place in the daily practice. 'It will be comparable to lab results. In future, we shall have various values from the CT scan, such as the degree of emphysema and the airway wall thickness. It may also be possible to measure the cardiac calcium score. Body composition, for example the amount of fat and muscle mass, may also be able to be determined from the CT scan. In future, respiratory physicians may be able to use that to decide whether or not to initiate and continue a treatment.'

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