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Quantitative computed tomography in the assessment of pathophysiology, status and outcome of patients with Acute Respiratory Distress Syndrome

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Quantitative computed tomography (qCT) constitutes a numeric approach to the assessment of CT data sets. In recent years it has been widely used to assess common lung pathologies, however only few research groups applied this method to rare but severe pulmonary diseases like Acute Respiratory Distress Syndrome (ARDS). Moreover, despite all investigations, the translatability of radiological parameters and their relation to real clinical measurements remained vague.
Therefore the aim of this study was to investigate the value of quantitative CT in the assessment of patients with ARDS. For this purpose, we aimed at elaborating those qCT parameters which best represent important aspects of ARDS pathophysiology and combined them for a comprehensive assessment of a patient's status and outcome.
28 intubated patients with ARDS obtained a non-contrast enhanced, single energy chest CT. Additionally, 14 of these patients received an iodine-enhanced dual energy CT scan. In order to create comparable data, all image acquisitions were performed during an end-expiratory breathhold manoeuvre. The acquired images were then analysed in order to generate quantitative CT parameters pertaining to lung ventilation, perfusion and lung weight, respectively. Simultaneously to the CT scans clinical measurements (such as blood gases, applied ventilation pressures, pulse contour cardiac output measurements etc.) were collected and correlated with the qCT parameters for clinical validation. Furthermore, status and prognosis scores (SOFA, SAPS II) were collected for each patient on each day throughout their stay on intensive care unit and multiple regression analysis was performed to enable a prediction of these scores by a single CT scan.
Of all examined qCT parameters, excess lung weight (ELW) displayed the most significant results. Together with the amount of inflated lung tissue [%] and total lung CM enhancement, it constituted the best parameter for the assessment of lung weight, ventilation and perfusion, respectively. A strong association with the amount of extravascular lung water (EVLW) ($p<0.0001$; $r=0.72$) revealed ELW's ability to serve as a non-invasive parameter for the quantification of lung oedema. In accordance with the central role of pulmonary oedema in ARDS pathophysiology, ELW displayed strong correlations to all sorts of clinically relevant parameters. A comparison with PaO_2/FiO_2, the current standard to determine ARDS severity, proved ELW to be superior in assessing a patient's status in all its facets. This superiority was especially evident in the case of established status and prognosis scores, where ELW displayed a strong correlation with both the patients' mean SOFA- ($p<0.0001$, $r=0.69$) and SAPS II-Score ($p=0.0005$, $r=0.62$). Based on the concomitant potential to estimate a patient's outcome, a combination of quantitative CT parameters was used to generate a formula for an accurate prediction of a patient's SOFA score ($r^2=0.85$ %).
In conclusion, it can be stated that quantitative CT constitutes a valuable tool in patients with ARDS. It enables a comprehensive assessment of ARDS pathophysiology and an accurate prediction of a patient's status and outcome. In this regard, especially the parameter ELW needs to be emphasised. It seems to have a major impact on all different aspects of ARDS pathophysiology and bears a higher prognostic value than current standard PaO_2/FiO_2. For these reasons, ELW should be considered as a supplement to the current ARDS definition.