First results of spatial reconstruction and quantification of COVID-19 chest CT infiltrates using lung CT analyzer and 3D slicer

R. Bumm[1], A. Lasso[2], N. Kawel-Böhm[3], A. Wäckerlin[4], P. Ludwig[5], M. Furrer[1]
[1]*Department of Surgery, Cantonal Hospital Graubünden, Chur, Switzerland,* [2]*Laboratory for Percutaneous Surgery, The Perk Lab, Kingston, Jamaica,* [3]*Department of Radiology, Cantonal Hospital Graubünden, Chur, Switzerland,* [4]*Department of Intensive Care, Cantonal Hospital Graubünden, Chur, Switzerland,* [5]*Department of Pneumonology, Cantonal Hospital Graubünden, Chur, Switzerland*

Objective: Lung CT scans are early diagnostic tests in evaluation of COVID-19 patients. Data are usually analyzed visually and the extent of infiltrations can only roughly be estimated. The aim of the present study was to create a software to spatially visualize and quantify infiltrated and collapsed areas in lung CT scans and set these volumes into relation with non-affected lung areas.

Methods: A new software "Lung CT Analyzer" (LCTA, 1) was created from scratch in an international team-effort within the 3D medical imaging software 3D Slicer (2). LCTA consists of two components: "Lung CT Segmenter" implements an intuitive and semiautomatic workflow for the generation of lung masks. LCTA then uses masked thresholds of Hounsfield units to detect non-affected versus affected (emphysematous, infiltrated, and collapsed) areas of the lung. Intrapulmonary vessels are subtracted from the other volumes. Segment volumes are expressed in milliliters and displayed in 3D. COVID-Q was defined as affected divided by non-affected volume and can be calculated separately for both lungs.

3D Slicer and LCTA are open source, freely available and maintained on Github.

Results: CT data of twelve patients with moderate to severe COVID-19 (9 m, 3 f) were selected for the present retrospective study. All scans were performed shortly after admission. Thresholds of Hounsfield units (HU) for areas of interest were defined prior to the study and processing was identical for all patients. The median time effort for 3D reconstruction was 8 minutes per patient. For more detailed results please see the enclosed table. A 3D Slicer demo data set (Control) has been included for comparison.

Conclusion: The COVID-19 pandemic promoted fast-paced innovations such as LCTA in our hospital. LCTA was feasible, reproducible and easy to perform. COVID-Q correlated with COVID-19 lung involvement in all cases. All fatal cases showed COVID-Q values of > 2.0.

LCTA enabled the serial 3D reconstruction of infiltrated and collapsed lung areas in lung CT scans. The procedure may be of great help in the future analysis of pulmonary infiltrates of any cause. In COVID-19 disease, volumetric lung CT reconstruction could result in the definition of new prognostic factors, identify patients “at-risk” in the ICU, and be useful for follow-up.

(1) Lung CT Analyzer: https://github.com/rbumm/SlicerLungCTAnalyzer

(2) 3D Slicer: http://slicer.org