Semi-Automatic Workflows for Segmenting COVID-19 Lungs from CT Images

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Abstract

The objective of this study was to develop and compare two semi-automatic workflows for segmenting COVID-19 lungs from low-resolution computed tomography (CT) images at full inspiration and expiration. An additive and a subtractive method were examined using 3D Slicer software. Results indicated no difference in quality between the methods but do show a significant difference when comparing COVID-19 affliction severity in end-inspiration and end-expiration phases.

Methods (continued)

• Four-dimensional CT images of a patient hospitalized for COVID-19 at Vidant Medical Center in accordance with IRB-approved protocol.
• Segmentation performed in 3D Slicer software (slicer.org)²⁻³.
  • Two workflows for lobe and lesion segmentations
    • Additive workflow: More patient-specific but greater workload.
    • Region growing of lobes using the Margin tool and dynamic thresholding with manual addition of GGOs to each lobe.
    • Subtractive workflow: More efficient but less specialized.
    • Segmentation of full lungs using the Lung CT Segments module³ with manual addition of GGOs to each lung.
    • Subtracted lobe area from segmented lungs so that GGOs are included automatically using interactive lobe segmentation³.
  • Volumetric analysis of COVID-19 used the Lung CT Analyzer³.
  • Hounsfield unit (HU) thresholding, separated into consolidated COVID regions, ground glass opacities, and infiltrated regions.

Results

<table>
<thead>
<tr>
<th>Measurements in ml</th>
<th>Additive, end-inhalation</th>
<th>Additive, end-exhalation</th>
<th>Subtractive, end-inhalation</th>
<th>Subtractive, end-exhalation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volume</td>
<td>3658</td>
<td>3143</td>
<td>3589</td>
<td>3136</td>
</tr>
<tr>
<td>Inflated Volume</td>
<td>1864</td>
<td>1292</td>
<td>1864</td>
<td>1297</td>
</tr>
<tr>
<td>Affected volume</td>
<td>1794</td>
<td>1851</td>
<td>1725</td>
<td>1839</td>
</tr>
<tr>
<td>% affected</td>
<td>49.04%</td>
<td>58.89%</td>
<td>48.06%</td>
<td>58.64%</td>
</tr>
</tbody>
</table>

Conclusions

• This study demonstrates effective additive and subtractive semi-automatic workflows in 3D Slicer for COVID-19 lung lobe segmentation to be used in future studies investigating COVID-afflicted lung mechanics.

• Aerated lung volume decreases from end-inhalation to end-exhalation while COVID-affected volume persists, resulting in the appearance of higher severity at end-exhalation than end-inhalation. This indicates that the temporal characteristics of the respiratory cycle are important to consider when segmenting COVID-19-infected lungs.

References


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