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A Lung Volume-Based Perfusion SPECT and CT Comparison Algorithm for Enhanced Pulmonary Embolism Diagnosis

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I. BACKGROUND
Pulmonary Embolism (PE) is reported to be one of the most common cardiovascular diseases. It is caused by a blood clot that develops in a blood vessel elsewhere in the body and travels to an artery in the lung, forming a blockage [1].

Lung V/Q (ventilation/perfusion) SPECT is one of an established diagnostic imaging test for suspected PE. The idea behind this test is to administer patient the radioactive tracer intravenous or by inhalation and use a gamma camera to detect the radiation emitted. The regular CT is also often performed to improve diagnosis sensitivity and specificity [2].

II. PURPOSE
The goal is to develop an algorithm estimating lung volumes from Perfusion SPECT and CT examinations and calculate the ratio VP /VCT (Perfusion lung volume to CT lung volume). The assumption is that a low ratio may indicate the presence of regions with no perfusion, suggesting the patient may be suffering from PE. This algorithm may improve the sensitivity and specificity of PE diagnosis and introduces an automatically calculated metric quantifying the severity of potential PE.

III. MATERIALS AND METHODS
During our studies, we developed a method for calculating lung volumes using two complementary imaging modalities: SPECT and CT. Our dataset comprised 5 patients —3 diagnosed with Pulmonary Embolism (PE) and 2 healthy controls. Both scans were available for each patient, acquired through our collaboration with the Warsaw Military Institute of Medicine.

Data processing involved analysis of DICOM files containing both CT and SPECT images along with their associated metadata. For segmentation, we employed distinct approaches tailored to each modality: SPECT images were segmented using a standardized fixed threshold method, while CT images were processed using an established machine learning algorithm based on transfer learning of U-net architecture, implemented through the lungmask [3] library. We improved the CT segmentation process by converting pixel values to Hounsfield Units (HU) as a crucial preprocessing step. Lung volumes for both imaging modalities were calculated using the physical voxel dimensions from the image metadata. This dual-modality approach ultimately enabled us to calculate the Perfusion/CT ratio based on the segmented volumes.

IV. RESULTS
The developed algorithm successfully distinguished between PE-diseased and healthy patients. The maximum volume ratio observed in the diseased group was 0.695, while the minimum value in the healthy group was 0.869.

V. CONCLUSION
Although the algorithm effectively differentiated between

the two groups, the limited sample size suggests the need for further research and additional data to validate the findings, determine a reliable threshold, and establish fundamental metrics such as sensitivity and specificity.

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