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Usefulness of chest perfusion computed tomography in the diagnosis of diabetic pulmonary microangiopathy

Renata Kalicka [a,*], *Maciej Browarczyk* [a], *Seweryn Lipiński* [b]

[a] *Department of Biomedical Engineering, Faculty of Electronics, Telecommunications and Informatics, Gdańsk University of Technology, Gdańsk, Poland*

[b] *Department of Electrical and Power Engineering, Faculty of Technical Sciences, University of Warmia and Mazury in Olsztyn, Olsztyn, Poland*

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ABSTRACT

This paper presents the usefulness of perfusion computed tomography (pCT) in the diagnosis of diabetic pulmonary microangiopathy. Our previous works have shown that perfusion parameters are useful in the diagnosis of diabetic pulmonary microangiopathy. We are looking for such measurements and perfusion parameters that provide the most accurate diagnosis. Two types of comparison were made based on the results of clinical trials: non-diabetic vs. diabetic and diabetes without microangiopathy vs. diabetes with microangiopathy. Our studies have shown that *PS* (permeability surface) is only perfusion parameter statistically significant. In certain regions of interest logistic regression as a classifier produces very good results in diagnosing lung microangiopathy: sensitivity *Sens* = 89% and excellent specificity *Spec* = 100%. The results were obtained on the base of measurements taken from 23 subjects. These results were compared with results reported in the literature and based on diffusion capacity and spirometry measurements and modeling. None of the previous results was as good as those obtained using the *PS* and logistic regression for binary classification.

1. Introduction

Lung microangiopathy is a little known negative influence of diabetes mellitus on the functioning of the lungs. Currently lung microangiopathy is diagnosed by two-time measurement of pulmonary diffusing capacity in the standing and supine positions [1,2].

Attempts have been made to diagnose lung microangiopathy using spirometry, but studies [2–4] have shown that a single spirometry test does not provide sufficient information for a proper diagnosis. Instead a number of tests needs to be carried out over an extended time period.

Perfusion computed tomography (pCT) is a non-invasive diagnostic method that enables the imaging of the organs and tissue hemodynamics. It is used in the diagnosis of internal

* *Corresponding author at*: Department of Biomedical Engineering, Faculty of Electronics, Telecommunications and Informatics, Gdańsk University of Technology, 11/12 Gabriela Narutowicza St., 80-233 Gdańsk, Poland.
E-mail address: renata.kalicka@biomed.eti.pg.gda.pl (R. Kalicka).

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organs such as the brain, liver, pancreas, prostate, spleen, kidneys and lungs [5–11]. The method enables quantitative evaluation of circulation by determining changes in tissue during the flow of a contrast agent in the blood vessels. Perfusion is a significant indicator of how tissue functions. Changes, when compared to a normal tissue, can indicate tissue pathology.

2. Objectives

Our previous papers [11,12] have shown possibility of utilizing perfusion parameters in the diagnosis of diabetic pulmonary microangiopathy. Aim of this paper is to define conditions for precise and accurate diagnosis: selection of the most conclusive *ROIs* and choice of optimal discrimination threshold for binary classification.

3. Materials and methods

Set of measurement data consists pCT records on $M = 23$ never-smoking subjects. No participants had been diagnosed with any acute or chronic respiratory disease affecting pulmonary function. The test group (9 females and 14 males, aged 26–66) comprises of $M^{no\ diab}$ non-diabetics and M^{diab} diabetics. The diabetic group M^{diab} comprises patients without microangiopathy and patients with microangiopathy, $M^{diab} = M^{no\ angiop} + M^{angiop}$. The microangiopathy was diagnosed by measuring lung diffusing capacity with the subject standing up and lying face up [2].

All patients were subjected to chest perfusion computed tomography using a 64-row Light Speed VCT CT scanner (*GE Healthcare, USA*). Chest perfusion tests were performed after an intravenous injection of 40 ml of an non-iodinated contrast medium at a rate of 4 ml/s and with a delay of 12 s. The test consisted of 267 scans; 3 cross sections, i.e. 3 sets of 89 scans, see Fig. 1. The scans were taken with a temporal resolution of 1 s.

On the basis of the temporal sequence of the scans the following perfusion parameters, using software CT Perfusion 4 (*GE Healthcare USA*), were calculated:

1. *BF* [ml/100 g/min] – blood flow through 100 g of lung tissue in 1 min,
2. *BV* [ml/100 g] – blood volume in 100 g of lung tissue,
3. *MTT* [min] – mean transit time through the vascular system in selected region,
4. *PS* [ml/100 g/min] – permeability surface, the penetrability of blood from intravascular to extravascular space, observed in 100 g of lung tissue during 1 min.

Program CT Perfusion 4 uses standard markings: ROI_1 in pulmonary artery is considered as a reference point (*AIF* – arterial input function). ROI_2 is typically placed in an arterial vessel – not used in our analysis. The regions of interest ROI_i, $i = 3, \ldots, 20$ were located in both lungs, including their upper, central and lower parts and were manually chosen

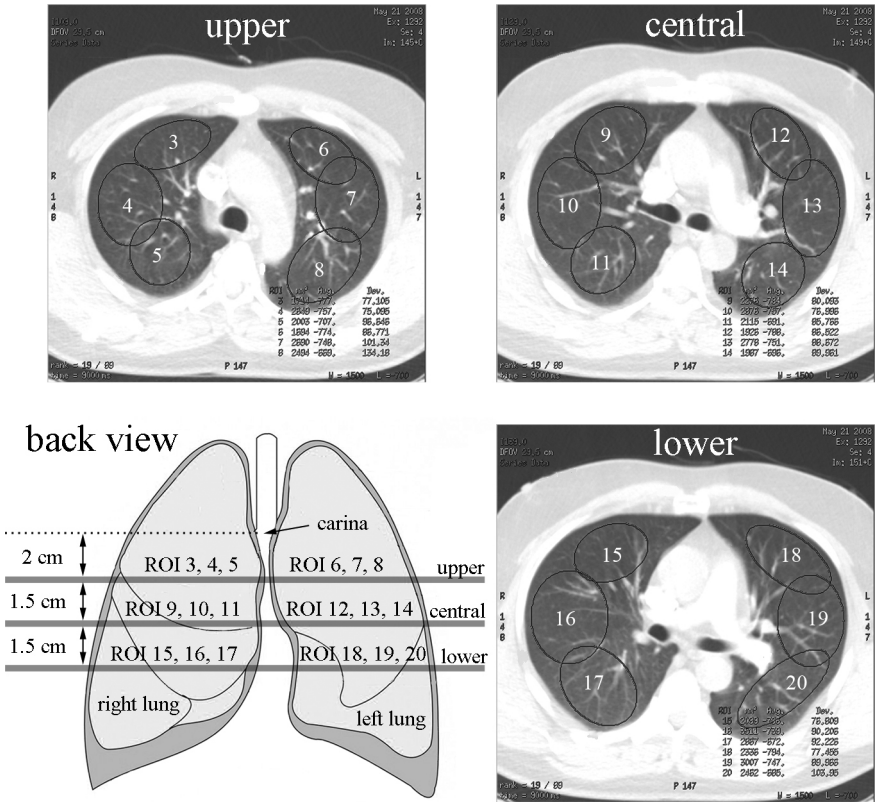

Fig. 1 – Cross sections of lungs with selected regions of interest numbered from 3 to 20, ROI_i, $i = 3, 4, \ldots, 20$ for upper, central and lower part of lungs situated 2 cm, 3.5 cm and 5 cm below carina, respectively.