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**„Ocena zmian w badaniach obrazowych układu oddechowego
i czynności płuc u chorych z niewydolnością serca”**

**Rozprawa na stopień doktora nauk medycznych i nauk o zdrowiu
w dyscyplinie nauki medyczne**

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Streszczenie w języku angielskim

Title: "Evaluation of changes in imaging tests of the respiratory system and pulmonary function in patients with heart failure."

Heart failure (HF) is a clinical syndrome caused by structural or functional abnormalities that lead to increased intracardiac pressure and/or decreased cardiac output. It is a common disease affecting up to 1-2% of the population, and this percentage is increasing yearly. The reason may be the high prevalence of HF risk factors, such as hypertension or obesity, and the ageing of the population. Due to its diverse etiology, this disease remains a major diagnostic and therapeutic challenge for clinicians.

Diagnosis of HF is based on the presence of signs and symptoms, features of cardiac dysfunction in echocardiography and/or an elevated value of the NT-proBNP, however, other additional tests may be necessary to make a final diagnosis, including electrocardiography, chest radiograph (CXR), as well as extended blood tests, and additional exercise and imaging tests. Many classifications are used to describe HF, but the most common one is based on echocardiography, according to the left ventricular ejection fraction.

HF significantly affects lung structure image through numerous pathophysiological mechanisms described in detail in the following thesis. The most common signs of HF include lung crackles, peripheral oedema, or increased pressure in the jugular veins, while the most frequently reported symptoms include shortness of breath, fatigue, or reduced exercise tolerance. The abovementioned symptoms are not characteristic for HF as they can be a manifestation of many other diseases, including lung diseases. This makes the proper diagnosis and differentiation between HF and respiratory diseases complicated. In addition, the impact of HF on lung structure and function makes it difficult to distinguish heart disease from lung disorders in everyday clinical practice. Most of the previous studies on this topic included patients with advanced HF with reduced ejection fraction (HFrEF), valvular disease or candidates for heart transplantation, while there are fewer studies on patients with compensated HF, especially those with heart failure with preserved ejection fraction (HFpEF). In this subgroup of patients, a high incidence of other comorbidities, including lung diseases, has been described. Therefore, there is still a need for further research on HF's impact on respiratory system changes.

The main goal of this thesis was to assess structural lung abnormalities, pulmonary function disorders and the incidence of newly diagnosed lung diseases in patients with chronic,

symptomatic compensated HF with symptoms I-III according to the NYHA scale, without previous respiratory diseases. The specific objectives were defined as follows: a) assessment of the frequency and spectrum of structural changes in the lungs found in imaging tests (chest computed tomography (CT), lung ultrasound (LUS) in patients with HF; b) assessment of the frequency and type of pulmonary function disorders in patients with HF; c) assessment of the incidence of previously undiagnosed lung diseases in patients with HF; d) assessment of differences in the occurrence of lung diseases in patients with HFpEF compared to other patients with HF; e) assessment of differences in the occurrence of respiratory function disorders in patients with HFpEF compared to other patients with HF; f) assessment of differences in the occurrence of structural changes in the lungs in patients with HFpEF compared to other patients with HF.

This doctoral thesis contains the results of a single-center, cohort observational study conducted at the Department of Internal Medicine, Pneumology and Allergology of the Medical University of Warsaw in 2018-2023, which included patients with chronic, compensated HF in the period of exacerbation of symptoms I-III NYHA, who had not been previously diagnosed with any respiratory diseases and in whom infection, severe kidney or liver disease were excluded. The diagnostic procedure included a physical and subjective examination as well as additional tests, e.g., basic laboratory tests, echocardiography of the heart, pulmonary function tests (PFT, i.e., spirometry, body-plethysmography, TLCO) and imaging tests (LUS and chest CT). The study protocol was approved by the Institutional Review Board of the Medical University of Warsaw (KB/126/2017) and all patients signed an informed consent to participate in the study.

The study included 61 patients (33 women, 28 men; median age 74 years old). Most of the study group consisted of patients with HFpEF (n = 40; 66%), followed by patients with HFrEF (n = 13; 21%) and HF with mildly reduced ejection fraction (HFmrEF; n = 8; 13%). Twenty-three (38%) patients were newly diagnosed with respiratory diseases, the most common of which were: chronic obstructive pulmonary disease (COPD; n = 6), interstitial lung diseases (n = 6), asthma (n = 5) and bronchiectasis (n = 5). Moreover, 6 patients had previously been diagnosed with obstructive sleep apnea. The most common HF-related abnormalities found on chest CT were: i) diffuse, heterogeneous increased lung parenchyma density (n = 28; 46%), ii) bilateral interlobular septal thickening (n = 27; 44%), and iii) mediastinal lymphadenopathy (n = 24; 39%). It was shown that more abnormal HF-related changes in the lungs on CT scans were found in patients with HFrEF than in patients with HFpEF (p = 0.027). Similarly, the highest number of lesions secondary to HF in the LUS examination (B-lines and

subpleural consolidations) were found in the group of patients with HFrEF ($p = 0.038$). There were no differences in the frequency of particular types of changes associated with HF on CT scans between patients with HFpEF, HFmrEF and HFrEF. Among all patients, the most common pulmonary function disorder was a decrease in TLCO ($n = 18$; 29.5%). There were no differences in the incidence of airway obstruction, restriction and TLCO impairment between patients with HFpEF, HFmrEF and HFrEF. On the other hand, patients with HFrEF had the lowest values of FEV1%N and FVC%N in spirometry and the lowest TLC%N in bodyplethysmography compared to other patients (FEV1%N $p = 0.017$; FVC%N $p = 0.002$, TLC%N $p = 0.048$, respectively).

Based on the obtained results, it was found that respiratory diseases are common comorbidities in patients with HF, and their spectrum is wider than COPD and sleep disorders. The coexistence of lung diseases applies to all types of HF, regardless of ejection fraction. Most structural changes detected in chest CT and LUS are found in patients with HFrEF, but the type of abnormality is similar regardless of the type of HF. Similarly, changes in respiratory function are the most common in patients with HFrEF, although airway obstruction, restriction, or impairment of TLCO are observed in all patients.

In conclusion, the type of functional changes in the respiratory system and structural changes secondary to HF in the lungs is similar in all types of HF, although more pronounced in patients with HFrEF. Due to the frequent coexistence of HF and respiratory diseases, it is necessary to carefully diagnose patients with HF in terms of respiratory diseases, considering functional tests of the respiratory system and imaging tests.