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Noninvasive hemodynamic evaluation of chronic obstructive pulmonary disease and heart failure patient

Nieinwazyjne badanie hemodynamiczne u pacjenta z niewydolnością serca i przewlekłą obturacyjną chorobą płuc

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Abstract

The noninvasive hemodynamic monitoring in patients with heart failure and chronic obstructive pulmonary disease was presented in this paper.

Key words: heart failure, COPD, impedance cardiography

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Introduction

A common symptom reported by patients is dyspnea — a subjective feeling of lack of air, difficulty breathing or shortness of breath. The sensation of breathlessness can be experienced in many diseases. In an outpatient setting, differentiating between the causes of dyspnea can be a diagnostic challenge and is usually based on physical examination, laboratory tests and imaging tests available in primary healthcare settings. Outpatient non-invasive hemodynamic monitoring has the potential to predict exacerbation of heart failure. Impedance cardiography (ICG) [1–3] and impedance scale are used in monitoring primary health care patients, which helps to differentiate between the causes of dyspnea in patients with heart failure (HF) and chronic obstructive pulmonary disease (COPD) [4, 5]. The aim of this study was to present the use of non-invasive monitoring of hemodynamic parameters in patients with COPD and coexisting HF [6].

ICG was used to assess hemodynamic parameters. This method is based on a change in the volume of blood pumped during the heart's cycle, causing a change in electrical resistance. Hemodynamic indices are calculated from the changes in the chest resistance, heart rate and blood pressure. The following parameters were used for the study: thoracic fluid content (TFC) [1/kΩ], contractility index (HI, Heather index) [Ω × s^{-2}], heart rate (HR) [1/min], stroke volume (SV) [ml] and cardiac output (CO) [l/min]; systemic vascular resistance (SVR) [dyn × s/cm^5] was also calculated. The pre-ejection period (PEP) [ms] and the left ventricular ejection time (LVET) [ms] were determined from the curve, and the contractility index was calculated based on the PEP/LVET ratio — the so-called Weissler index [7].

Case report

A 64-year-old patient, diagnosed many years ago with COPD and HF, was treated on an outpatient basis due to increasing dyspnea, decreased exercise tolerance and worsening of well-being. He was included in the AMULET program ("A new model of medical care with use of modern methods of non-invasive clinical assessment and telemedicine in patients with heart failure") [8]. In the 6 months preceding the visit, he was hospitalized due to an exacerbation of HF.

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The functional status of the patient was assessed according to the modified Medical Research Council (mMRC) apnea scale at level 3, and heart failure was assessed according to the New York Heart Association (NYHA) at grade II–III. The medical history revealed COPD (cat. B), paroxysmal atrial fibrillation, mitral valve insufficiency, chronic kidney disease (stage G3b), arterial hypertension, type 2 diabetes, mixed hyperlipidemia, Mallory-Weiss syndrome. The patient underwent the following procedures: percutaneous coronary intervention (PCI) of the left posterolateral branch (LPL) from the circumflex artery (Cx) (coated stent), PCI of the left anterior descending (LAD) (coated stent) and implantation of a resynchronization pacemaker. The patient denied alcohol consumption; however, he had smoked a pack of cigarettes a day for 50 years (50 pack-years), but had not smoked for the last 6 months. Pharmacotherapy during stabilization state included: amiodarone, metoprolol, potassium chloride, metformin, rivaroxaban, torasemide, ramipril, budesonide, and iprathiopium bromide.

The physical examination at the first visit showed a body weight of 75 kg and a height of 169 cm. The waist circumference was 102 cm and the body mass index (BMI) was 26.3 g/m^2.

An electrocardiogram (ECG) showed a paced rhythm of 80/min, and an X-ray of the chest showed an enlargement of the heart and visible signs of stasis. Echocardiography showed an increased diastolic left ventricular-diameter of 73 mm, increased left atrial diameter of 59 mm and a left ventricular ejection fraction reduced to 23%.

The following results were obtained in laboratory tests: B-type natriuretic peptide (BNP) — 524 pg/mL, ferritin — 124 μg/L, iron — 37 μg/dL, thyroid-stimulating hormone (TSH) — 2 μg/L, white blood count (WBC) — 11 × 10^9/L, red blood count (RBC) — 3.3 × 10^{12}/L, hemoglobin (Hb) — 10 g/dL.

The patient underwent ICG three times at monthly intervals. This study compares the results obtained during all the examinations (Figures 1, 2).

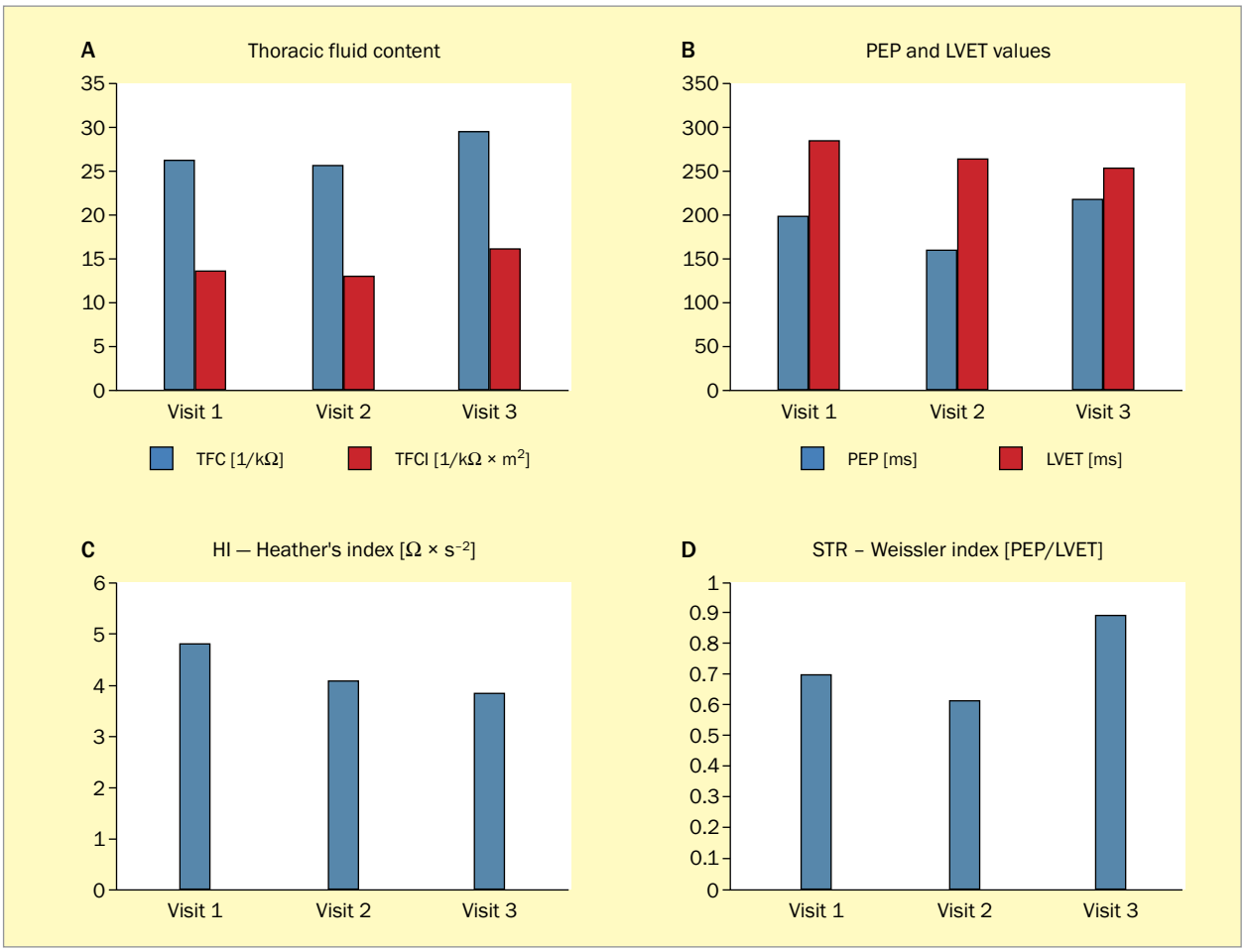

Figure 1A–D. Preload [thoracic fluid content (TFC)] and myocardial contractility in a patient with heart failure and chronic obstructive pulmonary disease; TFCI — thoracic fluid content index; PEP — pre-ejection period; LVET — left ventricle ejection time; STR (systolic times ratio) — contractility coefficient/Weissler index

The assessment of the cardiovascular system was based on the analysis of changes in preload, myocardial contractility, CO and afterload characterized by SVR. Thoracic fluid content decreased slightly on the second examination and increased significantly on the third visit. Relative preload changes were determined using the ΔTFC. Compared to the first examination, the result obtained in the third visit increased by 11.94%.

Cardiac contractility was assessed by HI and the PEP/LVET ratio. It was noticed that HI was 5 times lower than the lower limit of normal — it oscillated between 4.8 and 3.9. The relative decrease in contractility between Visit 1 and Visit 3 was 18.75%. The contractility abnormalities are also reflected in the increase in the Weissler index. According to Czaplicki et al. [7] the PEP/LVET ratio is a sensitive, classic indicator of myocardial contractility. There was a clear increase in the value of Weissler index during the third examination. The relative deterioration reflected in the increase of this index, was 27.14% [7]. Systemic vascular resistance was within normal limits.

The obtained picture of hemodynamic changes indicated that the cardiac pump function was preserved despite critical disturbances in contractility. Presumably, the preservation of cardiovascular function resulted from the change in preload, in accordance with the Frank-Starlig law. Studies suggest that a slight increase in preload may cause a breakdown in cardiac contractility and pump function [7]. Based on the telephone interview, information was obtained about the patient's death.

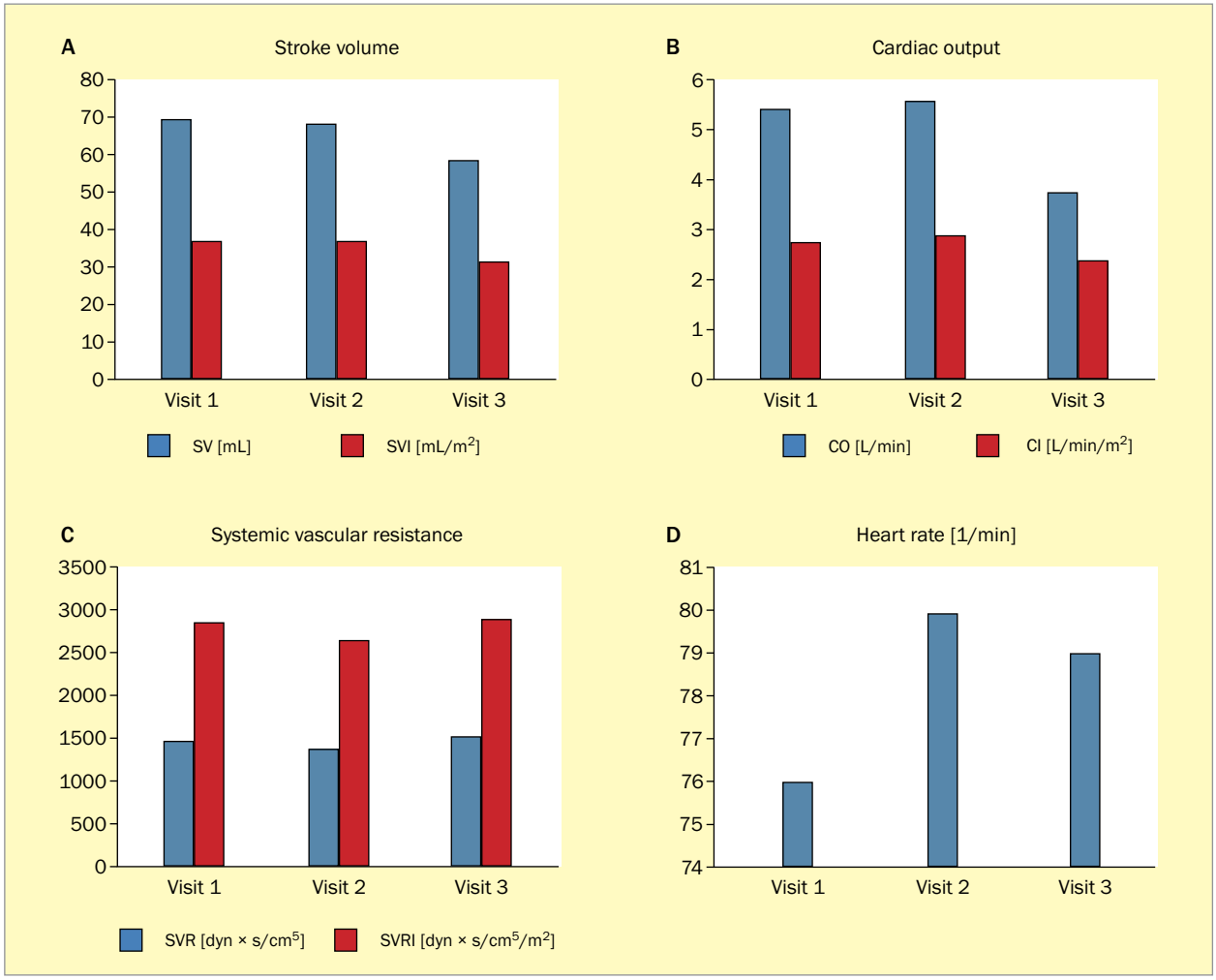

Figure 2A–D. Stroke volume (SV), cardiac output (CO), and systemic vascular resistance (SVR) in a patient with heart failure and chronic obstructive pulmonary disease; SVI — stroke volume index; CI — cardiac index; SVRI — systemic vascular resistance index

Summary

The analysis of the results presented above shows that the deterioration of the patient's condition was mainly due to hemodynamic disturbances, and not to exacerbation of COPD.

The presented application of non-invasive cardiovascular examination in patients with coexisting HF and COPD may provide information useful for differentiating between the causes of clinical deterioration. Examination with the use of ICG in an outpatient setting may be performed by mid-level medical staff.

Funding

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Streszczenie

W pracy przedstawiono zastosowanie nieinwazyjnej oceny hemodynamicznej u chorego z niewydolnością serca i przewlekłą obturacyjną chorobą płuc.

Słowa kluczowe: niewydolność serca, POChP, kardiografia impedancyjna

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