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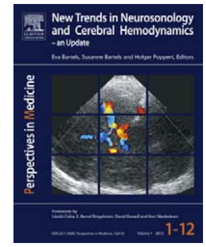

Cerebral blood flow in the chronic heart failure patients

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KEYWORDS
Cerebral blood flow;
Carotid Doppler;
Chronic heart failure;
Left ventricle ejection fraction

Abstract
Background: Global cerebral blood flow (CBF), as a measure of cerebral perfusion, can be non-invasively studied using Doppler sonography. Chronic heart failure (CHF) increases the risk of stroke and dementia. One of the possible causes may be cerebral hypoperfusion in CHF patients. Therefore, we aimed to investigate the relationship between CBF and CHF severity.
Methods: The study was performed in 76 ischemic or idiopathic dilatative cardiomyopathy patients, left ventricular ejection fraction (LVEF) < 40%, with no clinical evidence of decompensation and 20 healthy volunteers. Each CHF patient was categorized according to the New NYHA criteria. All patients underwent Doppler echocardiography examination (GE Vivid 7). The LVEF was quantified using the Simpson method. CBF was estimated by a 7.0-MHz linear transducer of a computed sonography system (Toshiba Power vision 6000). CBF volume was determined as the sum of the flow volumes of the ICA and the VA of both sides.
Results: Atrial fibrillation was noted in 30%, left bundle branch block in 26%, while pacemaker was implanted in 9% of patients with CHF. History of myocardial infarction was presented in 64% of patients. No differences in age, waist/hip ratio, body mass index and lipid profile were found between CHF patients and healthy subjects. CBF was calculated in 71 of 76 patients. Three patients had occlusion of ICA, while VA was occluded in another two patients. Others did not have a hemodynamically significant ICA and VA stenosis. CBF volume was decreased in CHF patients, (677 ± 170) according to control (783 ± 128).
Conclusion: Our results of noninvasive sonographic measurement of CBF according to LVEF and NYHA criteria, suggest on significantly reduced CBF in CHF patients.

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Introduction

Brain dysfunction associated with structural brain changes, are the important but under-recognised complication of chronic heart failure (CHF) [1—3]. In addition, CHF increases the risk of dementia and Alzheimer disease in later life [4]. One of the possible causes may be cerebral hypoperfusion secondary to low cardiac output in patients with CHF apart from biohumoral, clinical, socio-demographic and other potentially relevant factors [5,6]. Cerebral blood flow (CBF), as a measure of cerebral perfusion, can be noninvasively studied by flow volume measurements in extracranial cerebral arteries using Doppler and duplex methods [7]. Relationship of CBF to different markers of heart failure severity was only modestly presented in previous papers. Therefore, we aimed to investigate the relationship between CBF and CHF severity as well as to evaluate its determinants among different parameters of cardiac dysfunction.

Methods

Study design

Based on reviewed medical history archives on the baseline visit we screened 152 males aged 55 years and above with CHF due to ischemic or idiopathic dilated cardiomyopathy. Following the baseline visit 76 patients were selected all of whom met the study inclusion criteria. Inclusion criteria were as follows: duration of CHF for longer than 1 year; echocardiographically assessed left ventricular ejection fraction (LVEF) < 40%; etiology of CHF: ischemic or idiopathic dilated cardiomyopathy; NYHA functional class II and III; unchanged medication regimen within the previous 6 weeks; clinically stable condition with no clinical evidence of decompensate heart failure, such as raised jugular venous pressure, ascites, hepatomegaly. Exclusion criteria were as follows: diabetes mellitus determined by either self reported histories or evidence within the hospital case notes; primary lung disease including chronic obstructive pulmonary disease; musculoskeletal diseases; uncontrolled hypertension of more than 170/110 mmHg; myocardial infarction or unstable angina within previous 3 months; acute or chronic infection, inflammatory diseases such as sepsis, arthritis or systemic connective tissue disease; symptomatic peripheral vascular disease; alcohol abuse; serum creatinine 200 mmol/l; valvular cardiomyopathy or artificial heart valve; malignant disease, significant liver, thyroid, suprarenal gland or pituitary disease; cardiac cachexia defined as unintentional weight loss of 7.5% body weight over 6 months [8]. Finally, we included 71 patients because 3 patients were characterised by occlusion of internal carotid artery, while vertebral artery was not visualised in 2 patients.

The control group consisted of 20 healthy male volunteers aged 55 years and above, who did not take medications. No previous medical illness was reported (including diabetes or any other cardiovascular disease).

Clinical, cardiovascular and carotid color duplex sonography assessment

After the patient gave his written consent, the medical history was reviewed, including the cause of heart failure, comorbidities and medical history. Each patient with CHF was categorised according to the New York Heart Association (NYHA) criteria [9]. A physical exam was performed to assess CHF stability. The 6-min walk test was performed according to the standard protocol [10].

All patients underwent a two-dimensional Doppler echocardiography examination (GE Vivid 7). Systolic function was quantified by measurement of LVEF using the Simpson method. We also measured left ventricular end-diastolic diameter (LVEDD), right ventricular systolic pressure (RVSP) and left atrial volume (LAV) according to the ASE recommendation [11].

During an initial 20 min of rest with the subjects in a supine position, the extracranial arteries, i.e., the common carotid arteries, internal carotid arteries (ICA) and the vertebral arteries (VA) of both sides were explored with a 7.0 MHz linear transducer of a computed sonography system (Toshiba PowerVision 6000). The examination followed a previously described protocol [7]. CBF volume was determined as the sum of the flow volumes of the ICA and the VA of both sides. Resistance index, as a measure of cerebrovascular resistance, was calculated as follows: (peak systolic velocity end diastolic velocity)/peak systolic velocity [12]. Included subjects did not have hemodynamically significant stenosis of the common carotid artery, ICA and VA. The peak systolic velocity value averaged from both ICA and VA was used, as well. Intima-media thickness was measured on the far wall of the right and left common carotid artery, the carotid bulb, and the ICA [13]. The carotid intima-media thickness was defined as the mean of intima-media thickness measurements at these six sites.

Quality of life was estimated from The 'Minnesota — Living with Heart Failure Questionnaire' [14]. The Tei index is defined as the sum of isovolumic contraction and relaxation time divided by the ejection time. This index is a sensitive indicator of overall cardiac dysfunction in patients with mild-to-moderate CHF [15].

Statistical analysis

Descriptive statistics were presented as mean values with standard deviation or median with interquartile range for numeric variables, or as absolute numbers with percentages for categorical variables. Evaluation of normality was performed with Kolmogorov—Smirnov test. Student *t*-test was used to calculate differences between mean values. Mann—Whitney *U*-test was used to determine differences between median values. The Pearson coefficient was used for measuring linear correlation between variables. Partial correlation analysis was performed to adjust for age and body mass index. Finally, since variables are inter-related, multivariate regression analysis, backward method, was performed to assess the independent variables that may explain CBF. A *p* value 50.05 was considered to indicate statistical significance. Statistical analysis was performed using the