運動負荷時の中心動脈圧波形の解析に基づく新しい血管内皮機能評価法の確立と評価基準の作成

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Assessment of Vascular Endothelium Function Based on the Analysis of Central Arterial Pressure Waveform during Dynamic Exercise

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ABSTRACT

The aim of this study was to investigate the usefulness of the central arterial pressure waveform measured during dynamic exercise in the evaluation of peripheral vasodilatory dysfunction of individuals at the early stage of hypertension. We examined ninety-five volunteers (42±9 years) composed of normotensive and untreated hypertensive subjects who had resting blood pressure (BP) ranging from the normal to stage 1 hypertension. They exercised for 10 min on a bicycle ergometer at a heart rate (HR) equal to 50% of their HR reserve. At baseline, immediately (<1 min) and 5 min after the dynamic exercise, the peripheral pulse waveforms were recorded by

a radial applanation tonometry. Central pressure waveforms were estimated using a generalized transfer function. Pulse pressure（PP）amplification, defined as the ratio of peripheral to central PP, was used as a marker of wave reflection. Endothelium-dependent peripheral vasodilatory response was assessed as flow-mediated dilation of the brachial artery. Compared to the resting state before exercise, the PP amplification significantly increased at the end of exercise, and thereafter it gradually decreased toward the baseline level. Before the exercise, the hypertensive subjects showed the lower PP amplification than normotensive subjects（1.32 vs. 1.46, P<.001）, and the differences between groups became more prominent at the end of exercise（1.66 vs. 1.85, P<.001）. When the subjects were divided into subgroups according to the tertiles of PP amplification after exercise, the subjects in the bottom tertile showed significantly reduced flow-mediated dilation（7.5±2.5%）than those in the intermediate and top tertiles（9.3±2.6% and 10.9±2.4%, P=.026）. Multivariate regression analysis revealed that the low PP amplification（β=0.435, P=.002）was independently associated with the decrease of flow-mediated dilation, independent of age, body mass index, brachial systolic BP, HDL-cholesterol, and HbA1c（R^2=.381, P<.001）. These results suggest that the response of central arterial pressure waveform during dynamic exercise is associated with peripheral vasodilatory dysfunction and hence may be useful as a marker of subclinical vascular alterations in the early stages of hypertension.

要　旨

本研究では，運動負荷中の中心動脈圧波形の解析に基づく血管内皮機能の評価法の有効性について検討した．対象者は脳・心血管疾患，糖尿病，腎疾患の治療歴がなく，血圧が正常域またはⅠ度高血圧にある健康な成人男性 95 名（平均年齢 41.9±8.7 歳）であった．運動負荷試験は自転車エルゴメーターを使用し，50%の相対心拍数に相当する強度で 10 分間の固定負荷運動を行った．負荷試験中は左上腕部より上腕血圧を測定するとともに，負荷前，終了直後および 5 分後にトノメトリ法による橈骨動脈の圧波形の記録を行った．さらに，この波形を一般化伝達関数により大動脈起始部の圧波形に変換して中心血圧を求め，橈骨動脈と中心動脈の脈圧比を反射指数とした．対象者を負荷終了 5 分後の脈圧比の 3 分位数（tertile）で分類して比較した結果，血管内皮機能の指標の FMD（内皮依存性血管拡張反応）は，低位群＜中位群＜高位群の順に連続的に高値となり群間に有意な差が認められた．また，FMD を従属変数とした重回帰分析において，脈圧比は年齢，BMI，上腕収縮期圧，HDL コレステロール，HbA1c の補正後も独立の有意な規定因子であった．以上のことから，運動負荷中また終了後の中心動脈圧波形には，運動誘発性の血管拡張反応が反映され，その波形変化を解析することで内皮機能の低下などの早期の血管障害を適切に評価できることが示唆された．