水中での不整脈発現と安全基準に関する研究
—水位と呼吸制限の相互作用—

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A Comparison of the Occurrence of Arrhythmias and Varying Cardiovascular Responses Among Middle-Aged and Young Individuals During Head-Out Water Immersion

by

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ABSTRACT

To investigate the changes in cardiovascular responses by different breathing frequencies between a group of seven middle-aged (68 ± 7 years) and five young (21 ± 2 years) healthy subjects during head-out water immersion. Electrocardiograms recorded continuously data at four different breath frequencies, 4, 6, 10 and 15 cycle per minute (4C, 6C, 10C and 15C), at three levels of immersion, head-out navel, breast and shoulder where a given value of end-tidal P_{CO_2}(P_{ETCO_2}) when the subjects spontaneously breathed was regulated in all conditions with

fixed tidal volume (V_T) of 1.5 L. Beat-by-beat heart rate (HR), stroke volume (SV), cardiac output ($\dot{Q}$), systolic and diastolic blood pressure (SBP and DBP), and breath-by-breath V_T and P_{ETCO_2} were simultaneously measured during the experiment. During water immersion, HR was decreased significantly in young group, whereas HR was not altered in middle-aged group. By contrast, SV was increased significantly in young group and while these changes did not reach the significant level in middle-aged group. Consequently, $\dot{Q}$ showed a tendency to increase in middle-aged group during water immersion, not in young group. SBP and DBP were not markedly changed in middle-aged group. These findings suggested that cardiac parasympathetic nerve activity was enhanced and sympathetic nerve activity was suppressed at head-out water immersion in young group, otherwise, in middle-aged group, cardiac autonomic nerve activity would not markedly be changed by head-out water immersion. These responses were unaffected by the different breath frequencies. Four middle-aged subjects developed arrhythmias, e.g., premature ventricular (PVC), and premature atrial contraction (PAC) at higher head-out water immersion. We concluded that increased water pressure during immersion could induce a higher preload into the heart, i.e., increased $\dot{Q}$ in middle-aged group, subsequently might provoke arrhythmias.

要　旨

水浸位の異なる環境（臍部，胸部，肩部）において，早い呼吸頻度から遅い呼吸頻度まで呼吸パターンの変化（呼吸頻度；4，6，10，15回/分の4種類，一回換気量；1.5 L固定）について中高齢者群と若年者群との比較検討から，中高齢者の水中環境での循環応答の特徴について明らかにした．水浸によって，若年者群の心拍数（HR）は，臍部ですでに有意な低下が観察され，そのレベルは胸部および肩部でもほぼ同程度であった．中高齢者群の水浸によるHRの低下と一回拍出量（SV）の増大は若年者群ほど顕著にみられず，胸部，肩部において心拍出量（$\dot{Q}$）の若干の増加傾向が観察されただけであった．異なる呼吸パターンの循環応答への影響はいずれの水浸条件でもほぼ同じ程度であり，水浸の影響が呼吸パターンのそれを凌駕していたようである．不整脈（PAC, PVC）の発現は中高齢者群のみに認められた．水圧の上昇による静脈還流の増大が心臓の前負荷を亢進し，中高齢者の不整脈発現に影響した可能性が考えられる．