

听觉诱发脑电小波分量的混沌研究——婴儿痉挛症认知功能障碍的机制探讨

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通过对婴幼儿期难治性癫痫——婴儿痉挛症 (infantile spasms, IS) 听觉诱发脑电细貌混沌特性的研究, 探讨与IS相伴的认知功能障碍的发生机制。研究方法是分别记录IS组及正常对照组对象的听觉诱发脑电, 经 Mexihat连续小波变换后, 分别计算信号各尺度小波分量的相关维数。结果表明IS组与正常对照组的各小波分量相关维数的差别主要表现在小波的第3尺度分量上(频带范围是32~64 Hz, 主要为 γ 频带范围), 在这个尺度上正常组相关维数明显低于IS组 ($P < 0.05$)。相关维数的降低意味着大脑活动自由度的减少, 表明大脑的各单元耦合加强。因为正常组脑干内信息传递通道完好, 使得大脑各个单元之间的信息耦合较强; IS组则由于脑干功能的异常, 存在神经信息传递障碍, 进而影响到脑干及其与大脑各个局部之间的信息耦合。小波第3尺度处于较高频率范围 (γ 频带范围), 而在大脑皮层上的基频信号与听觉调频信号经加工后所产生的神经信号正在这一频率范围, 且这一信号与大脑高级认知功能密切相关。因此, IS患者 γ 频带细貌信号的相关维数高于正常值, 能够解释IS认知功能发生障碍的原因。

Infantile spasms is a special form of epilepsy, which occurs during infancy. The pathogenesis of infantile spasms has not been known yet. However, when infantile spasms is associated with structural damage to the brain, it is difficult to completely control the seizures and intellectual, and cognitive impairment is very likely to be present. One of current hypothesis about the pathogenesis of IS is that brainstem is the responsible structure of IS, the reason why most IS suffers cognition impairment is still unknown. The pathogenesis as well as the accompanied cognition impairment of IS has been approached from the view of information science, with the help of the wavelet and chaos theory. IS and normal groups' evoked EEGs were recorded with the auditory stimulation. After pre-process and Mexihat wavelet transform were performed, the EEG signal was decomposed into different components in 7 scales, and their correlation dimensions (D_c) were calculated. The results show that the normal group's D_c in three scale is significantly lower than that in the IS, in other scales no significant difference has been found. It is known that the freedom degree of brain activity becomes lower and the coupling among the components in brainstem reinforces when D_c declining. In the IS group, the pathway of information in brain stem is in bad condition. This makes the coupling more difficult. So D_c in the IS shows higher than that in the normal in three scales. Meanwhile, the 3,4 scales are in the high frequency range (32~64 Hz), which is relative to the brain cognition function. From informatics it is may be explained why IS infants always accompany with cognition impairment. The conclusion can be drawn that the abnormal EEG signal in gamma frequency in IS may cause the cognition impairment in IS.

关键词

婴儿痉挛症 (Infantile spasms (IS)); 听觉脑干诱发脑电 (Auditory brain-stem evoked EEG); 认知功能障碍 (Cognition impairment); 小波变换 (Wavelet transform); 相关维数 (Correlation dimension (D_c))