

# 哇巴因作用下窦房结放电节律的非线性特征

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运用近似熵及非稳定周期轨道方法, 观察哇巴因(ouabain)对大鼠窦房结放电节律的影响, 研究窦房结放电节律的非线性动力学特征。结果显示: 应用5  $\mu\text{mol/L}$  ouabain 引起窦房结放电先出现不规则节律后, 放电频率增加又转化为规则放电节律, 窦房结放电间期由  $(394 \pm 16)$  ms 缩短到  $(295 \pm 13)$  ms; 随后放电节律再次转为不规则, 最后窦房结放电间期又转为不规则。窦房结放电间期的近似熵值也随ouabain引起放电节律的不规则程度而增大; 应用30  $\mu\text{mol/L}$  ouabain 时有周期2、3及严重不规则节律的出现, 并在严重不规则节律中检测到不稳定周期1、2及3轨道; 用40  $\mu\text{mol/L}$  ouabain 后则可引起窦性停搏。结果表明ouabain 可使窦房结放电序列出现多种节律, 其中不规则放电节律含有确定性机制。

## NONLINEAR CHARACTERS OF FIRING PATTERN FROM SINOATRAL NODE DURING OUABAIN PERFUSION

In order to study the nonlinear characters of firing pattern from sinoatrial node (SA) during ouabain perfusion, ApEn (approximate entropy) and UPOs (unstable periodic orbits) were employed to measure IBI (interbeat interval) from SA firing. The results show that when 5  $\mu\text{mol/L}$  ouabain was applied, IBI became irregular first, then the SA firing frequency accelerated and changed to regular pattern, the IBI decreased from  $(394 \pm 16)$  ms to  $(295 \pm 13)$  ms correspondingly; after that the IBI became irregular again; In the end, the IBI changed from regular pattern to a little irregularity. The ApEn varied with the changes of IBI; When sinoatrial node was exposed to 30  $\mu\text{mol/L}$  ouabain, period 2, 3 and irregular rhythm appeared; Among irregular rhythm UPOs (1, 2, 3) were identified; 40  $\mu\text{mol/L}$  ouabain could stop the firing of sinoatrial node. From above results, It can be concluded that the firing rhythm of SA during ouabain perfusion was based on determinant mechanism.

### 关键词

哇巴因(Ouabain); 窦房结(Sinoatrial node); 近似熵(Approximate entropy); 不稳定周期轨道(Unstable periodic orbits)