

百日咳毒素对棉铃虫神经细胞电压门控钠、钙通道的调节作用

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用膜片钳技术研究了百日咳毒素对离体培养的棉铃虫幼虫中枢神经细胞电压门控钠、钙通道的影响。结果表明, 对照组细胞钠通道在 $-50\sim-40$ mV激活, 在 -20 mV左右电流达到最大值, 在记录的20 min内, 电流-电压关系曲线(I-V)和电流幅值未有明显变化; 细胞与百日咳毒素预孵后, 钠通道在 -40 mV左右激活, 电流在 0 mV左右达到最大值, 在记录过程中, 激活电压和峰值电压继续向正方向移动约 10 mV, 电流持续下降。对照组钙通道在 $-40\sim-30$ mV激活, 在 0 mV左右电流达峰值; 经百日咳毒素处理后, I-V曲线向负电位方向移动约 10 mV, 在记录过程中, I-V曲线继续向负电位方向移动, 电流的衰减(rundown)现象比对照组严重, 此外, 百日咳毒素处理引起钙电流达到峰值的时间显著延长。结果提示, 百日咳毒素敏感的G蛋白(G_i)可能通过直接途径或间接途径调节棉铃虫神经细胞钠、钙通道的电压敏感性和开放几率以及钙通道由备用态向激活态转化的速度。同时, 经百日咳毒素处理后钠通道的I-V曲线与抗性棉铃虫I-V曲线非常相似, 可能暗示 G_i 蛋白在棉铃虫抗药性形成中发挥作用。

MODULATION OF THE VOLTAGE-GATED SODIUM AND CALCIUM CHANNELS BY PERTUSSIS TOXIN SENSITIVE G_i PROTEIN IN NEURONS ISOLATED FROM COTTON BOLLWORM (*Helicoverpa armigera*)

The modulation of voltage-gated sodium and calcium channels by pertussis toxin (PTX) sensitive G_i protein in the central neurons isolated from three instar larvae of the *Helicoverpa armigera* was studied using whole-cell patch clamp technique. Sodium channels were activated when the membrane potential was depolarized to $-50\sim-40$ mV and the current reached peak value at about -20 mV in control. During the 20 min of recording, little change was shown in I-V relationship curves and peak value as well. Pretreated with pertussis toxin, however, sodium channels were activated at about -40 mV and current reached peak value at about 0 mV. Moreover, the I-V curve was continually shifted in positive direction during the recording. In addition, the peak current decreased to $(70.92\pm 8.76)\%$ of initial peak value by the end of 20 min recording. Calcium channels were activated when the membrane was depolarized to $-40\sim-30$ mV and the current was maximized at about 0 mV in control. After treatment with PTX, I-V curve was shifted approximately 10 mV in negative direction and the shift was continued during the period of recording. Rundown in current was more apparent than that in control. The time course to reach peak current for calcium channels was obviously prolonged by PTX treatment. Taken together, the results suggested that G_i protein modulates voltage sensitivity and open probability of sodium and calcium channels via direct or indirect pathways, and affects the rate of gating from closed state to the active in calcium channels. Furthermore, it was noticeable that the I-V shift of sodium channel in PTX-treated neurons was significantly similar to that of resistant cotton bollworm, which indicated that G_i protein might participate in the evolution of resistance to insecticide.

关键词

棉铃虫(*Helicoverpa armigera*); Na^+ 通道(Sodium channel); Ca^{2+} 通道(Calcium channel); G_i 蛋白(G_i protein); 百日咳毒素(Pertussis toxin); 全细胞膜片钳(Whole-cell patch clamp)