THE BASIS OF TRIGGERED ACTIVITY
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Triggered activity is a type of impulse generation that requires the prior occurrence of one or more action potentials for its initiation (1). It differs from automaticity, which requires no preceding electrical activity for its initiation other than spontaneous depolarization of the membrane until it attains threshold potential. Hence, a major differentiator between automatic and triggered rhythms is the spontaneity of the former in contrast to the obligatory dependence on preceding electrical activity of the latter.

The initiating event for triggered activity is an afterdepolarization; two distinct subtypes of which have been identified: early and delayed (Fig. 1). These are distinguished from one another by their timing with respect to the repolarization of the action potential: an early afterdepolarization is an oscillation which occurs prior to full repolarization of the membrane (i.e. during phases 2 or 3); a delayed afterdepolarization is an oscillation that follows the termination of repolarization (i.e. occurring during phase 4).

EARLY AFTERDEPOLARIZATIONS

Early afterdepolarizations can be induced by any intervention that diminishes outward, repolarizing current and/or augments inward, depolarizing current. These include slowing the stimulus rate, exposure to catecholamines (2), reducing potassium concentration (3), and/or adding cesium (4), reducing pH (5,6), lowering calcium concentration (7), hypoxia (8), and exposure to drugs such as aconitine (9), N-acetylprocainamide (10) or sotalol (11).

As defined above, early afterdepolarizations differ from automaticity in that automaticity can and does arise de novo in cells that were previously quiescent; whereas, early afterdepolarizations require a preceding action potential for their initiation. We recently have studied the response of early afterdepolarization-induced arrhythmias to pacing (12). The afterdepolarizations are cycle length dependent in that their amplitude tends to increase as drive rate decreases below the physiological range. However, if

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Figure 1A. Early afterdepolarizations. These oscillations were induced by superfusing a canine Purkinje fiber bundle with cesium, 5 mM, while driving at a slow cycle length. Temp. 37°C.

drive rate is made sufficiently low, the afterdepolarizations again decrease in amplitude. Hence, there is a window of stimulation rates (of about 10-30 beats/min) at which the amplitude of early afterdepolarizations is largest. Moreover, within this window of cycle lengths, the slower the preceding drive rate, the more rapid and sustained is the rhythm that is induced by the early afterdepolarizations.

Once an early afterdepolarization attains threshold and initiates a triggered rhythm, the rhythm tends not to be overdrive suppressed by brief periods of pacing (12). The reason for this can be best understood if we first consider the basis for overdrive suppression in normal cardiac fibers. When normal fibers at a high level of membrane potential are overdriven, the rapid pacing increases the number of action potential upstrokes occurring per unit time. The upstrokes of action potentials occurring at high levels of membrane potential are the result of Na⁺ ion entry into the cell; hence, overdrive pacing increases the total amount of sodium entering the fiber per unit time (13). One of the major stimuli for sodium-potassium pumping is the entry