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Spatiotemporal characteristics of atrial Ca^{2+} sparks: evidence from two-dimensional rapid confocal imaging

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Atrial myocytes have two functionally separate Ca^{2+} release sites: those in peripheral sarcoplasmic reticulum (SR) adjacent to the Ca^{2+} channels of surface membrane and those in central SR not associated with Ca^{2+} channels. Study on the spatio-temporal properties of focal Ca^{2+} releases ("sparks") occurring spontaneously in central and peripheral sites of voltage-clamped rat atrial myocytes, using rapid two-dimensional (2-D) confocal Ca^{2+} imaging revealed that peripheral and central sparks were similar in size and release time (~300,000 Ca^{2+} ions for ≅12 ms), but significantly larger and longer than ventricular sparks. Both sites were resistant to Cd^{2+} and inhibited by ryanodine. Peripheral sparks were brighter and flattened against surface membrane, had ~5-fold higher frequency, ~2 times faster diffusion coefficient, and dissipated abruptly. Central sparks, in contrast, occurred less frequently, were elongated along the cellular longitudinal axis, and dissipated slowly. Compound sparks (composed of 2-5 unitary focal releases) aligned longitudinally, occurred more frequently at the center. The diversity of peripheral and central sparks with respect to shape, frequency and speed of spatial development and decay is consistent with regional ultrastructural heterogeneity of SR. The retarded dissipation of central atrial sparks, and high prevalence of compound sparks in cell center maybe critical in facilitating the propagation of Ca^{2+} waves in atrial myocytes lacking t-tubular system and provide the atrial myocytes with functional Ca^{2+} signaling diversity.