Spontaneous Ca and electrical signals in the renal pelvis that drive pelviureteric peristalsis

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Electrical rhythmicity near the base of the papilla in the renal pelvis provides the fundamental drive for the peristaltic contractions that propel urine from the kidney to the bladder for storage before micturition. The histological identification of atypical smooth muscle cells (ASMCs) within these proximal regions of the renal pelvis has often been used to suggest that these cells are the pacemaker cells driving pelviureteric peristalsis. We have separately recorded the electrical activity and associated Ca^{2+} transients in ASMCs using intracellular microelectrodes and the fluorescent Ca^{2+} indicator fluo-4. These spontaneous activities were compared with the equivalent activity in the typical smooth muscle cell (TSMC) wall responsible for the peristaltic contractions. Nifedipine (1-10 μM)-sensitive action potentials and Ca^{2+} waves propagated through the TSMC muscle layer at a velocity of 1 mm•s^{-1} and a frequency of 5-10 min^{-1}. High frequency (>10-40 min^{-1}) spontaneous transient depolarizations (STDs) and Ca^{2+} transients in short spindle shaped cells were resistant to nifedipine blockade and did not propagate over distances >50 mm. STDs and Ca^{2+} transients in ASMCs were blocked in Ca^{2+} free solutions and upon blockade of the Ca^{2+}ATPase pump with cyclopiazonic acid (CPA). STD and Ca^{2+} transients were abolished upon blockade of IP_3 dependent Ca^{2+} store release, but only partially reduced upon blockade of ryanodine receptor Ca^{2+} release channels. STDs were little affected by agents that block pacemaker currents in cultured intestinal interstitial cells of Cajal, La^{3+} and Gd^{3+}, the Cl^- channel blocker, DIDS or upon removal of 85% of the extracellular Cl^-. We speculate that ASMCs act as the primary pacemaker signal in the renal pelvis by generating Ca^{2+} transients and cation selective STDs. In addition, ASMCs appear to be providing point sources of excitation to the TSMC layer.