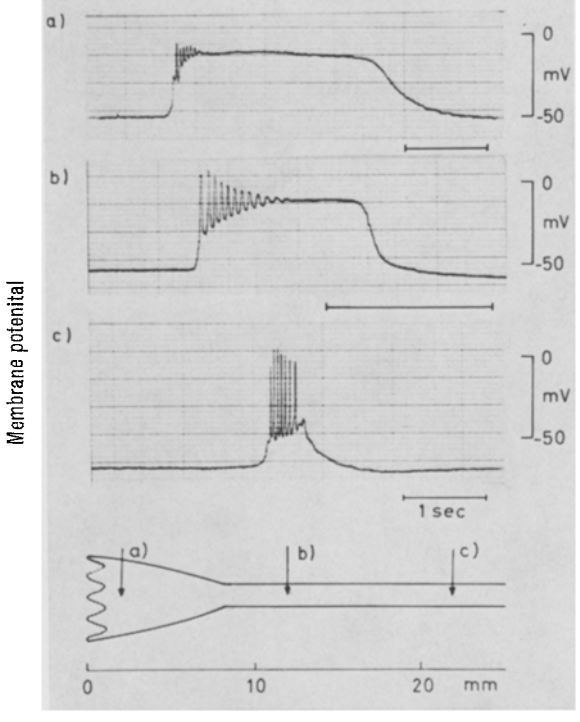
Electrical Activity in Different Regions of the Pyeloureteral System in the Guinea-Pig

The action potential of the ureter shows remarkable differences from species to species[1–3]. We have now tested to what extent systematic differences exist in the action potential at different parts of the pyeloureter of one and the same species.

Material and methods. From 33 guinea-pigs a kidney and ureter were cut out and transferred, for further preparation, to a bath with cool storage solution (Na^+ 144, K^+ 5.9, Ca^{2+} 3.7, Cl^- 157 mmol/l). The renal pelvis was prepared up to the utmost renal ends which contain the normal pacemaker[4]. For measurement of the membrane potential in the ureter, the distal end of the preparation was pulled over a thin perspex rod and secured. The rod was fixed to the bottom of a perfused organ bath and the free end was connected to a mechano-electrical transducer. Electrical and mechanical activity were then recorded simultaneously on a direct recorder (Fa. F. Schwarzer, Munich). Different fixation techniques were used for intracellular measurements in the region of the renal pelvis. In some cases, the renal pelvis was pulled over large perspex cones expecially adapted to the renal pelvis form; in other cases, parts of the renal pelvis were secured to a small round perspex plate, or the pelvis was fixed with pins to a cork plate. Glass microelectrodes were used for intracellular measurements, the whole technique being similar to that described for portal vein preparations[5]. The organ bath was perfused with the following solution: Na^+ 137, K^+ 5.9, Ca^{2+} 2.5, Mg^{2+} 1.2, Cl^- 124, HCO_3^- 25, $H_2PO_4^-$ 1.2, glucose 11.5 mmol/l, equilibrated with 95% O_2 and 5% CO_2, pH 7.4, temperature 35 °C.

Results and discussion. During long-term recording at the same place of a pyeloureter preparation, the action potential remained quite constant, but great differences were found in action potentials measured at different regions, as demonstrated in Figure 1. The differences concern the duration of the whole action potential as well as the height of the plateau depolarization and the spike amplitude. The distal action potential (Figure 1c) can, as is usual in the literature, be described as spikes superimposed on a plateau component. However, the action potential of a more proximal region (Figure 1b) appears as a uniform process: an abrupt periodically damped transition to a plateau depolarization. The frequency of the oscillation was 20–30 cps. This is in good agreement with the results of VEREECKEN[3]. Measurements in the renal pelvis region are technically more difficult than in the ureter itself. Successful long-term recordings in this area could be obtained in 2 out of 18 experiments. In both cases, the plateau duration was between 2 and 3 sec, which is longer than ever observed in ureter smooth muscle (15 experiments, plateau duration 0.5–1 sec.) In the experiment of Figure 1a), a continuous recording with the same penetration was made over 9 min, and 21 action potentials were recorded in this period, all of which had a plateau duration of more than 2 sec, independent of whether the interval between 2 peristaltic waves was 12 sec or a multiple of it[4]. This can be taken as an indication that the recording of Figure 1a) represents the normal action potential in the renal pelvis region. The conclusion can be drawn that, in the proximal parts of the pyeloureter, the plateau component is particularly strong and of long duration and becomes weaker towards the distal parts; and that the spike-like oscillatory component is weak in the proximal section and becoming more pronounced towards the distal parts. These changes are not necessarily completely even over the whole length of the pyeloureteral system. It appears that the pyeloureteral junction is a point where a relatively sudden change occurs from one type to another.

The primary pacemaker is localized in the utmost renal ends of the renal pelvis[4]. The successful recordings were taken from a slightly more distal region, which can be described as a secondary pacemaker area: it is able to produce spontaneous activity, but at a lower rate than the primary pacemaker. We therefore assume that the recording of Figure 1a) gives already a good approximation of the action potential of the primary pacemaker area. It is to be expected that the predepolarization before the action potential, which was very small in the recording of Figure 1a), is greater in the primary pacemaker region, and perhaps the oscillatory component is even smaller than in Figure 1a).



Action potentials recorded with intracellular microelectrodes in different regions of the pyeloureteral system of the guinea-pig, as illustrated diagrammatically below. Recordings from different experiments. Note the differences in time scale.

Zusammenfassung. Bei intrazellulären Messungen des Aktionspotentials ergaben sich starke Unterschiede zwischen den verschiedenen Regionen des Pyeloureters: Die Plateau-Komponente ist proximal am stärksten ausgeprägt und wird nach distal hin schwächer, während die Oszillationen (Spikes) distalwärts ausgeprägter werden.

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