Ureteral Electromyogram in Normal and Hydronephrosis Rats

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In our hydronephrosis rat strain, the lesion has been categorized into types I and II according to degree of dilatation of renal pelvis [8, 9]. The type I is a severe cystic hydronephrosis and the type II is characterized by varying degree of pelvic dilatation and medullary loss. No ureteric obstruction has been found in both types. The amount of the pelvic urine has been noted to increase with age, especially in type I.

The pelvic urine is transported to the urinary bladder by ureteral peristalsis, which is controlled by the renal pelvic pacemaker. The impulses generated in renal pelvis pass the pyeloureteral junction (PUJ) and are spread from proximal to distal end of the ureter, which can be monitored by electromyogram (EMG). In relation to the urine accumulation with age seen in our type I hydronephrosis, we wonder if there is some dysfunction in the urine transporting ability in the ureter. The present study describes the ureteral EMGs recorded in situ at proximal, middle and distal points of the ureter as one of the functional presentations.

Twenty adult male animals, weighing 397.5 ± 56.4 g, were used. Under light ether anesthesia the femoral vein was catheterized for intravenous administration of pentobarbital sodium at 40 mg/kg. The abdominal wall was widely dissected and turned on the thorax. The ureters were carefully exposed. After insertion of a tracheal catheter, the animals were placed in an electrically sealed box. Ureteral EMGs were recorded using aspiration polyethylene tube (PE-10; Clay Adams, Parsippany, N. J., U.S.A.) microelectrode (silver/silver chloride) placed on the proximal end (p), the middle part (m) and the distal end (d) of the ureter. An indifferent electrode was placed into the scrotum and 2

ground wires were connected to the dissected abdominal wall. The electrocardiogram (ECG) were monitored using the bipolar lead. Respiratory movement (RM) could be read by upward and downward deflections of ECG base line. All electrical activities were simultaneously recorded using the Nihon Kodan High Gain A-C Amplifier AB-631G (time constant, 0.03s; Hi-cut, 30Hz) and 6 Channel Cardio Jet (specific frequency DC-1000Hz; Nihon Kodan Kogyo Co.). Schematic illustration of the experimental layout is indicated in Fig. 1. For calculation of the conduction velocity, distances between electrodes were measured by a slide vernier [10]. As to the hydronephrotic sides, the conduction velocity was calculated on the assumption that the discharges in m or d occurred as conduction of the preceding discharges in p or m, respectively. The pelvic volume was determined by the method of Josephson [3]. The only animals which sustained their heart-beats above 200 times per minute were subjected to be analyzed.

Normal side; Ureteral electrical activity was characterized by action potentials with triphasic form and seemed to coincide with the ureteral peristalsis as observed by naked eye, under the sound monitoring the discharge. The coincidence between the electrical activity and the peristalsis has been reported by Stower [7]. In the proximal end, EMG was approximately 0.61mV in amplitude, and occurred at intervals of 5 seconds, and

Fig. 1. Schematic illustration of the experimental apparatus layout.

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was conducted toward the middle part and the distal end of the ureter in a ratio of 1:1:1. The conduction velocity was approximately 20 mm/sec in both p-m and m-d (Table 1 and Figs. 2A, 2B).

Hydronephrotic side (type I); In the proximal end, EMG of approximately 0.18mV in amplitude which was lower than a third that of normal side, and occurred at intervals of 4 seconds. The conduction ratio was 4.5:1.7:1. The conduction velocity of p-m was approximately 10 mm/sec (Table 1 and Figs. 2C, 2D).

Hydronephrotic side (type II); In the proximal end, EMG occurred at intervals of 4 seconds, 0.30 mV in amplitude and the conduction ratio approximately 2.4:1.8:1 (Table 1 and Figs. 2E, 2F). These values were between those of normal and those of the type I. The conduction velocity was approximately 10 mm/sec in both p-m and m-d.

The mechanical and electrical activities in the ureteral smooth muscle and the renal pelvic pacemaker system has been fully investigated in the normal dog kidney. It has been identified that conduction of discharges between the inside of the renal pelvis and the ureter is accelerated by increases in urine flow, to shorten the interval of

ureteral EMG, but 1:1 conduction ratio of upper and lower ureter remains unchanged [6]. It has been confirmed that the ureteral EMG frequency and urine bolus volume are positively correlated in the dog [1, 4].

The present results obtained in the ureter of the normal side indicate 1:1:1 conduction of the EMG, suggesting the rat ureter has the similar functional relationship seen in the dog. In congenital hydronephrosis rat, ureteral EMG has not been measured. Even in the artificially induced hydronephrosis, there has not been reported on the breaking of the 1:1 conduction of EMG in the ureter, because the EMG was measured only at a single point [11]. Therefore, it is noteworthy that our hydronephrosis rat didn't show the conduction ratio (p:m:d) of 1:1:1 in both types. It is obvious that the affected rat shows ureteral dysfunction in conducting the electrical activities. This might result in unbalanced urine transportation, thus causing one of the reasons why the urine was accumulated in the pelvis of the type I hydronephrosis, although the causative relation between ureteral dysfunction and urine accumulation remains unclear.

Lower electrical activities recorded in the proximal end of the ureter of both types of

Table 1. Amplitude, interval and conduction velocity of the discharges recorded at the three points of the ureter in normal and hydronephrotic side

	Normal side	Hydronephrotic side	
		Type I	Type II
Number of examined	5	5	4
Pelvic volume (mg)	7.00±1.31	7163.24±5061.71 ^{a)}	456.18±277.96 ^{a)}
Amplitude of discharge (mV);			
p	0.61±0.09	0.18±0.06 ^{b)}	0.30±0.09 ^{b)}
m	0.79±0.17	0.43±0.18	1.02±0.23
d	0.37±0.07	0.16±0.04 ^{a)}	0.55±0.18
Interval of discharge (sec);			
p	5.28±0.76	3.76±0.27	3.36±0.40
m	5.29±0.76	10.17±5.33	4.49±0.63
d	5.32±0.76	16.83±6.95	8.18±1.24
Conduction velocity (mm/sec);			
p-m	23.54±3.59	13.00±1.52 ^{b)}	11.89±1.12 ^{b)}
m-d	20.60±2.63	24.25±3.87	13.02±1.17 ^{b)}

Mean±S.D.

p, proximal end of ureter; m, middle part of ureter; d, distal end of ureter.

a) Significantly different from normal side at $p<0.05$.

b) Significantly different from normal side at $p<0.01$.

Fig. 2. Ureteral EMGs recorded in normal (A, B) and hydronephrotic side (type I; C, D: type II; E, F). Recording speeds are 5 mm/sec (left) and 25 mm/sec (right) in all EMGs.

hydronephrosis rat are suggestive of some disturbances in generation of the action potentials or its conduction from pacemaker to ureteral smooth muscle via PUJ [2]. Further studies are needed to clarify this point, since type I hydronephrosis loses most of the renal medullary portion.

In order to explain the abnormal urine transportation, it is necessary to obtain informations on ureteral contractile activities, ureteral conduction velocity, peristalsis and bolus formation, ureteral innervation and urine components including bradykinin which induces ureteral con-

tractions *in vitro* [5].

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要 約

正常および水腎症ラットにおける尿管筋電図(短報): 濱田彰子・菊川馨一郎・鈴木勝士・本好茂¹⁾(日本獣医畜産大学獣医生理学教室, ¹⁾獣医内科学教室)——遺伝的に水腎症を発症するラットにおいて, 尿管の筋電図を吸引電極法により, 腎盂側(p), 中央部(m)および膀胱側(d)の3部位で同時記録した。水腎症側の尿管では腎盂側の放電の振幅が小さく, p→m→dにおいて必ずしも1:1:1の割合で伝播しなかったことから, 尿管の尿輸送機能の低下が腎盂尿の貯留を進行させる可能性が示唆された。