The carp and eels probably lose the same amount of blood as goldfish, however, the loss was negligible because of their larger body size and at least 10 times larger amount of blood. It is concluded that this osmometer system will have many uses in experimental biology involving even smaller animals than fishes, and will also be clinically applicable to examining such samples as children's blood, lymph, edema fluid, tissue fluid, etc.

1 This study was supported in part by Research Grant 387036 from the Ministry of Education of Japan.
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Conduction velocity of peristaltic waves in the in vivo ureter: application of a new diameter gauge

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Summary. The conduction velocity of peristaltic movements of the canine ureter was measured under anaesthesia with a new type of diameter gauge using an image sensor. The peristaltic velocity was 34.1 ± 6.2 mm/sec in 10 experiments. Noradrenaline at a low dosage of 1 μg/kg i.v. reduced the resting diameter, increased the conduction velocity to 47–56 mm/sec, and approximately doubled the frequency of contraction. The application of acetylcholine also caused an increase in both frequency and conduction velocity (42–46 mm/sec). A plot of the conduction velocity against the mean period of peristaltic contraction was hyperbolic in shape.

The activity of the ureter has been assessed in various ways, i.e., by measuring the conduction velocity, the frequency of peristaltic waves, or the changes of circumferential or longitudinal tension of the wall[2-5]. Such information cannot be acquired without causing some mechanical disturbance to the ureter like intubation for pressure measurement, or without making direct contact with its outer surface. We have recently constructed a diameter gauge utilizing the high resolving power and stability of the image sensor[6]. The device makes it possible to carry out contact-free diameter measurements of a cylindrical organ.

The purpose of this paper is to describe the use of 2 diameter gauges placed underneath the canine ureter in vivo to measure the peristaltic velocity and to study the effects of adrenergic and cholinergic agonists on the activity of the ureter.

Materials and methods. 15 mongrel dogs of both sexes, weighing 10–16 kg, were anaesthetized with pentobarbitone sodium (Nembutal, Abbott), 30 mg/kg i.v. A tracheal cannula was inserted, and the animal was ventilated with a Harvard respiration pump (Type 613). A femoral vein was cannulated with a polyethylene catheter for infusion of a physiological saline solution (infusion rate: 100 ml/h) and injection of drugs. The ipsilateral femoral artery was cannulated with a polyethylene catheter to record systemic arterial blood pressure by means of a pressure transducer (Toyo Baldwin MPU-0.5-290).

The left ureter was exposed from the renal pelvis to the bladder using a Flank approach into the retroperitoneum. The 2 diameter gauges were positioned at the proximal and distal portions of the exposed ureter. Conduction velocity of the contraction wave was calculated from the distance between the 2 gauges and the time interval between the onset of diameter reduction at each of the 2 positions. The construction and characteristics of the diameter gauge have been described elsewhere[6].

The drugs used were dl-noradrenaline hydrochloride (Sankyo Ltd) and acetylcholine chloride (Daiichi Seiyaku Ltd). All drugs were freshly prepared in saline and administered i.v. All doses are expressed as the weight of base per b.wt (μg/kg).

Results and discussion. Figure 1 demonstrates a typical in vivo recording of ureteral diameter changes at 2 positions. The diameter at the distal position (D2) first increased slightly, and then began to decrease 0.5 sec after the diameter at the proximal position (D1) had started to reduce. The distance between the 2 positions was 18 mm giving a conduction velocity for the peristaltic wave of 36 mm/sec. The average value of the velocity and its SE were 34.1 ± 6.2 mm/sec in 10 experiments.

In order to minimize the effect of contact, Constantinou et al.[7] recorded spontaneous action potentials of the ureters of dogs in vivo with very delicate, loosely attached electrodes. The average wave velocity thus obtained was about 45 mm/sec (20–60 mm/sec). Electrical changes other than the action potentials have often been included in records taken from the in vivo ureter, in dogs and human beings. These changes occurred in association with the passage of urine through the ureter[8]. In some cases, therefore, it is not easy to evaluate accurately the conduction velocity of the in vivo ureter by using the electrical signals recorded with bipolar electrodes.

Effects of noradrenaline and acetylcholine on the conduction velocity of the in vivo canine ureter were then examined. Noradrenaline (NA) was administered i.v. at a dosage of 1 μg/kg i.v. (figure 2, A). NA reduced the resting diameters at the 2 positions, increased the conduction velocity up to 47–56 mm/sec, and approximately doubled

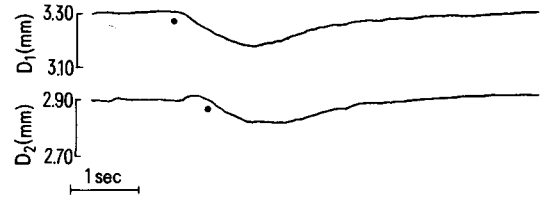

Fig. 1. 2 peristaltic diameter changes of the in vivo canine ureter. D1 and D2 show the diameter changes at the proximal and distal positions, respectively. Dots indicate starting points to reduce each diameter. The distance between the 2 positions is 18 mm.

the frequency of the ureteral contractions (5.1±0.9/min in control; 9.4±1.8/min in the presence of NA, n=5). The frequency change followed a time course similar to the change in systemic arterial pressure (SP) but the resting diameters returned to the control level much sooner.

Our results are consistent with those obtained by Rose and Gillenwater[9] who used a special arrangement enabling them to maintain the ureteric flow constant, irrespective of changes in renal output. They found that NA (1.75-2.50 µg/kg) stimulated the frequency and force of uretal contractions in the in situ canine ureter. The i.v. administration of acetylcholine (ACh) (20 µg/kg) (figure 2, B) caused a marked reduction of mean arterial pressure (about 70 mm Hg) and increased both the conduction velocity (42-46 mm/sec) and the rate of contraction (8.1±1.4/min, n=5). An increase in the frequency of ureteral peristalsis by ACh has been reported by Sleator and Butcher[8], Kiil and Kjekshus[10] and by Tsuchida et al.[11].

The response of the ureter to NA and ACh has been investigated in many species, but the results were conflicting[8-12]. Possible causes for the conflicting results may be as follows. 1. The ureter is a pressure sensitive organ, and a small change in pressure in the renal pelvis can affect the peristaltic activity. As the rate which urine is produced by the kidney is readily affected by the activity of th autonomic nervous system and by drugs which affect the autonomic neuro-effector system, it seems possible that some of the results may represent nothing other than the reaction of the ureter to changing rates of urine production. 2. The smooth muscle of the ureter is particularly susceptible to physical interference. The recording of ureteral activity is commonly carried out with an indwelling catheter, which has been shown to interfere with the normal functioning of the ureter[5]. 3. Autonomic innervation and responses of the postsynaptic membrane to autonomimetic agonists in the ureter differ among species and regions[13-16]. Also it seems likely that autonomic effects secondary to the changes in blood pressure may act directly on the ureter and modify its peristaltic movements.

The relationship between the conduction velocity and the mean period of peristaltic contractions of the ureter is summarized in figure 3. The curve has a hyperbolic form. The amount of scatter was larger in the range of the period beyond 10 sec, probably due to differences in the rate of urine production. The velocity of propagation was strikingly increased by the i.v. administration of NA or ACh. The mode of action of these agonists has not yet been clarified. It is hoped that further studies will determine their mode of action and the effect of the urine flow rate on the conduction velocity.

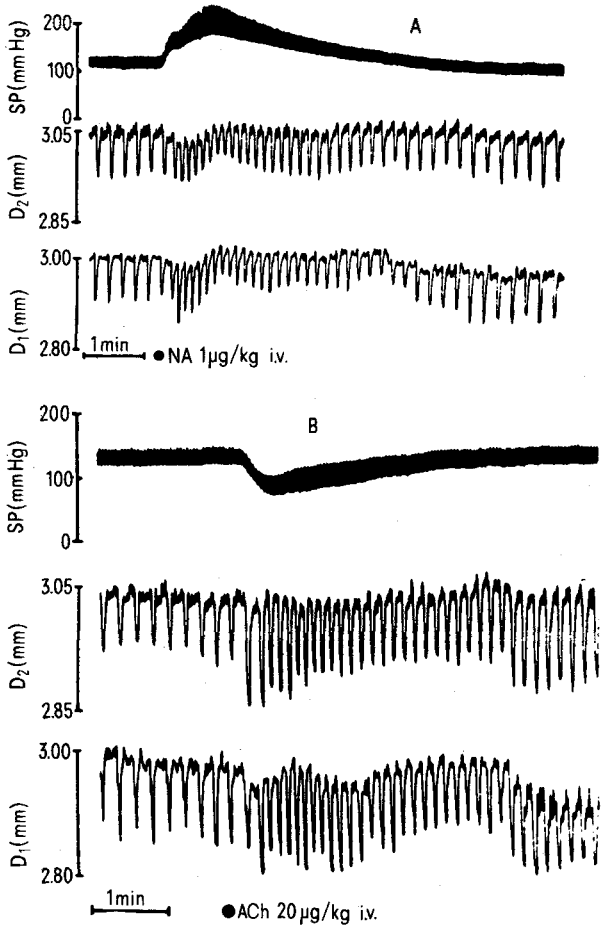

Fig. 2. Effect of noradrenaline (A) and acetylcholine (B) on arterial blood pressure (SP) and changes of the diameter of the in vivo canine ureter (D1 and D2). D1 and D2 indicate the same items as in figure 1.

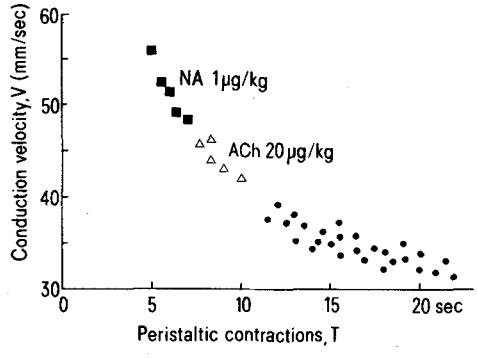

Fig. 3. The relationship between the conduction velocity (ordinate, V) and mean period of peristaltic contractions of the ureter (abscissa, T). Dots represent the controls. Triangles and squares denote the responses to acetylcholine (20 µg/kg) and noradrenaline (1 µg/kg), respectively.

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