Thai J. Physiol. Sci. 3(1), 17-25 (1990)

EFFECT OF CELERY ON KIDNEYS AND BLOOD PRESSURE IN DOGS

R. Musttayasuwan, A. Nakapaksin and S. Lhosiriwat

Department of Physiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 17000, Thailand

Abstract

The effect of Chinese Celery *(Apium graveolens Linn.)* decoction on kidneys and blood pressure was studied in dogs. A crude aqueous extract of celery was administered enterally to normotensive anaesthesized dogs (n = 10) while the control group (n = 8) was given distilled water. At the fourth hour after feeding, urine output, urine sodium and potassium excretion in the celery-fed group were significantly higher than those in the control group. On the other hand, glomerular filtration rate (GFR), renal plasma flow (RPF), arterial blood pressure and heart rate were not significantly different among the two groups. The results indicate that celery is a diuretic of slow onset. The diuresis is not caused by any changes in GFR or RPF, but rather from decreased tubular reabsorption of salt and water. Celery does not produce hypotension in normotensive anaesthesized dogs.

Key words : Celery, glomerular filtration rate, renal plasma flow, diuresis, hypotensive effect.

Introduction

Celery is a favourite vegetable which has been used by Thai people as food as well as an antihypertensive and diuretic agent. There are two forms of celery *(Apium graveolens* Linn., Family Umbellifereae). The large form, generally used by the American and European in soup or salad, is thicker, larger and slightly paler. The small form or Chinese variety known as KOENCHAI, which was used in this study, is much slimmer, dark green and quite aromatic. The Chinese Celery is an erect herb which grows up to thirty centimeters in height. The stem is short while the petioles are long giving off pinnated leaves with large and deeply-lobed segments. The whole plant except the roots is edible either cooked or fresh.

Kulshrestha et al. (1970) reported that an alkaloid fraction isolated from celery seeds showed anticonvulsant activity. Several Thai textooks of herbal medicine such as those written by Tantiwat (1978) and Muanwongyathi (1981) mentioned that celery was often used as a diuretic, aphrodisiac, carminative, appetizer, emenagogue and uterine stimulant. It has also been recommended in the treatment of bronchitis, asthma, rheumatism, amenorrhea, liver and spleen diseases. But the efficacy of all medicinal plants needs valid scientific support before any physician should prescribe them to his patients.

It has been shown that celery extracts produced hypotension in dogs and rabbits when injected intravenously (Pachotikarn et al., 1976; Shiengthong et al., 1979). Intravenous injection of celery decoction not only brought down blood pressure but also caused diuresis in rabbits and rats (Limpinuntana & Chai-arj, 1977). Enteral administration of celery decoction also decreased blood pressure and cardiac output in dogs (Chulakarat & Kolatat, 1978).

Even in hypertensive animal models such as in renal vascular occlusive dogs and DOCA-salt hypertensive dogs, feeding of celery decoction brought down blood pressure within sixty min without any effect on plasma renin activity. Diuresis occurred at the third h. after celery feeding and persisted for at least three h (Baramee & Lohsiriwat, 1987; Itsaramathangkurn & Lohsiriwat, 1987).

The purpose of the present study was to examine the effect of celery on kindey functions in terms of renal plasma flow, glomerular filtration rate, urine flow and electrolyte excretion.

Materials and Methods

Preparation of a crude aqueous extract of celery

A bunch of fresh celery was purchased from Salanarmron market in Bangkok. The roots were discarded, only fresh stems, petioles and leaves were used. The celery was washed several times with tap water, soaked in a dilute vegetable rinsing solution (Lipon-V®, coconut ether sulphate modified solution) for fifteen min to wash out any insecticides or contaminating substances, and then washed again several times with tap water. The cut fresh plant was weighed and then boiled in distilled water for one hr with frequent stirring to yield a decoction. The decoction was filtered and the volume was adjusted by adding distilled water or evaporation to make its volume to 400 ml per one kg fresh celery. The decoction was frozen in a freezer (-20° C) in 200 ml aliquots. Each aliquot was thawn at room temperature when needed.

Animal preparation

The experiment was carried out in 27 mongrel dogs, weighing 8.5-1.8 kgs, randomly divided into two groups : the control group (water fed, $n = 8$) and the experimental group (celery fed, $n = 19$). Each dog was deprived of food for twelve h but given water ***ad libitum.*** It was anaesthesized by intravenous pentobarbital sodium (Nembutal®, Abbott, FE Zuellig Bangkok Ltd.) 25 mg per kg body weight. A tracheostomy was done to maintain an airway passage. The righ jugular vein was cannulated to collect blood samples when needed. The left femoral artery was cannulated for continuous recording of arterial blood pressure using a P-100-A pressure transducer and a polygraph (E & M Instrument Co. Inc., Houston, Texas). The left femoral vein was likewise cannulated for infusion of solutions

A midline abdominal incision was made and both ureters were exposed and cannulated to collect urine directly and promptly from the kidneys.

Clearance technique

Five percent dextrose in normal saline solution (30 ml per kg body weight) was infused within 30 min to hydrate the animal initially, then the infusion was maintained at a rate of 100 ml per h. A priming dose of 100 mg PAH (para-amino-hippuric acid, E. Merck Co.) in 20 ml normal saline solution adjusted to pH 7.4 was given intravenously. This was followed by continuous infusion of 5% dextrose in normal saline solution containing 1.3 g PAH per litre. The maintenance infusion rate was 2.5-3.3 ml per min.

Experimental protocol

The experiment for both the control group and the celery-fed group was divided into two periods: pre-feeding period of 1h, and after-feeding period (either water feeding or celery feeding) of another 4 h.

The pre-feeding period started about 90 min after PAH priming after which PAH was continuously infused. Arterial blood pressure was recorded. Urine samples were collected at 30 min intervals throughout. Heparinized and non-heparinized blood samples were drawn at the midpoint of each urine collection period, then centrifuged to yield plasma or serum for further chemical study.

A gastric tube was inserted orally into its stomach for feeding. The control dogs (n = 8) were fed with water 20 ml per kg body weight, while the experimental dogs (n = 19) were fed with celery decoction. The after-feeding period commenced at the time the feeding was accomplished.

During the 4-h period after-feeding, blood pressure and urine volume were recorded while urine samples and blood samples were collected as in the pre-feeding schedule.

Serum and urine samples were analyzed for creatinine concentration by the Folin-Jaffe's alkaline-picrate method using a Gemstar instrument (Elliott Process Automation Ltd., London).

Sodium and potassium concentrations were assayed using a Nova 4 eletrolyte analyzer (Nova biomedical Co., Massachusetts).

PAH in plasma and urine samples were analyzed by the benzaldehyde method (Brun, 1951).

Clearance of creatinine and PAH were calculated using the standard clearance formula as $C = \frac{UV}{P}$, where

C = clearance of a substance (ml/min)
U = concentration of the substance in urine (mg/100 ml)
V = urine flow rate (ml/min)
P = concentration of the substance in plasma or serum (mg/100 mg)

The creatine clearance and PAH clearance are universally known to represent glomerular filtration rate (GFR) and renal plasma flow (RPF), respectively.

Analysis of data

The data analyzed were systolic and diastolic blood pressure, heart rate, urine volume, urine and serum electrolyte concentration (Na^+, K^+), GFR, RPF and filtration fraction. These parameters were analyzed as pre-feeding and after-feeding data obtained from 27 dogs. The animals were classified into two groups : group I (n = 8) was the control group (water-fed), while group II (n = 19) was the experimental group (celery decoction-fed). The pre-feeding data at 30 min and 60 min were averaged and used as one single pre-feeding baseline.

All data obtained in both control and experimental groups in concomitant periods were compared using the Student's t-test for unpaired data. The Student's t-test for paired data was used when parameters of the pre-feeding and after-feeding periods were compared for each animal. Data are reported as the mean value $\pm$ standard error of mean ($X \pm SEM$). A p-value of 0.05 is taken to be statistically significant.

RESULTS

Effect on blood pressure and heart rate

The blood pressure and heart rate showed no statistical differences between both groups, and remained rather constant throughout the experimental period whether celery was given or not (Table 1).

Effect on kidney function

The urine flow rate increased after feeding in both groups. In the water-fed dogs, urine volume showed a transient increase during the 1^{st} and 3^{rd} h after feeding (Fig. 1) while, in the celery-fed dogs, urine volume was maintained at a high flow rate and increased further after the 3^{rd} h. Unfortunately, the duration of diuresis was not monitored further. It is not known for how long the diuresis would persist.

During diuresis, urine sodium and potassium excretions were also higher in the celery-fed dogs when compared to the corresponding periods for the control dogs (Fig. 1).

Serum sodium and potassium concentrations gradually increased throughout the experiment in the celery-fed dogs whereas those in the water-fed group remained constant (Table 1).

Mathematical calculations of GFR, RPF and filtration fraction yielded similar data between the two animal groups at concomitant periods (Fig. 2). GFR and RPF increased to the same magnitude and same duration before returning close to the baseline. One can clearly see that celery-induced diuresis commenced by the time the GFR and RPF had already decreased to the baseline.

Table 1. Systolic and diastolic blood pressure, heart rate, serum sodium and potassium concentrations in the control (Group I, n = 8; water-fed) and celery-fed dogs (Group II, n = 19) at various time after feeding.

Parameter	Group	Pre-feeding	After-feeding (min)							
			30	60	90	120	150	180	210	240
Systolic Press	I	164 ± 1.5	166 ± 1.5	168.1.4	169 ± 1.4	168 ± 1.5	166 ± 1.6	163 ± 1.6	161 ± 1.6	161 ± 1.6
(mmHg)	II	165 ± 1.3	161 ± 1.3	162 ± 1.3	164 ± 1.4	166 ± 1.4	166 ± 1.5	169 ± 1.8	168 ± 1.9	169 ± 1.9
Diastolic Press	I	84 ± 1.9	83 ± 1.9	84 ± 1.9	84. ± 1.8	84 ± 1.9	83 ± 1.9	81 ± 2.0	80 ± 2.0	80 ± 2.0
(mmHg)	II	87 ± 1.2	85 ± 1.2	85 ± 1.2	85 ± 1.2	85 ± 1.2	85 ± 1.3	86 ± 1.5	88 ± 1.5	89 ± 1.6
Heart Rate	I	151 ± 1.5	151 ± 1.5	150 ± 1.5	150 ± 1.5	150 ± 1.4	154 ± 1.5	153 ± 1.4	153 ± 1.4	153 ± 1.4
(beat/min)	II	151 ± 1.1	148 ± 1.0	147 ± 1.3	147 ± 1.1	146 ± 1.7	147 ± 1.2	147 ± 1.3	153 ± 1.4	153 ± 1.4
Serum Na^+	I	144 ± 0.8	143 ± 0.7	144 ± 0.8	144 ± 0.8	144 ± 0.8	144 ± 1.4	144 ± 0.7	144 ± 0.6	144 ± 0.7
(mmol/L)	II	144 ± 0.6	145 ± 0.5	144 ± 0.6	145 ± 0.6	145 ± 0.6	146 ± 0.6	148 ± 0.7	148 ± 0.7	148 ± 0.7
Serum K^+	I	3.2 ± 0.2	3.2 ± 0.2	3.2 ± 0.2	3.3 ± 0.3	3.4 ± 0.3	3.2 ± 0.3	3.4 ± 0.3	3.4 ± 0.3	3.4 ± 0.3
(mmol/L)	II	3.2 ± 0.2	3.4 ± 0.2	3.7 ± 0.2	3.8 ± 0.2	3.9 ± 0.2	4.0 ± 0.2	4.3 ± 0.2	4.6 ± 0.3	4.9 ± 0.3

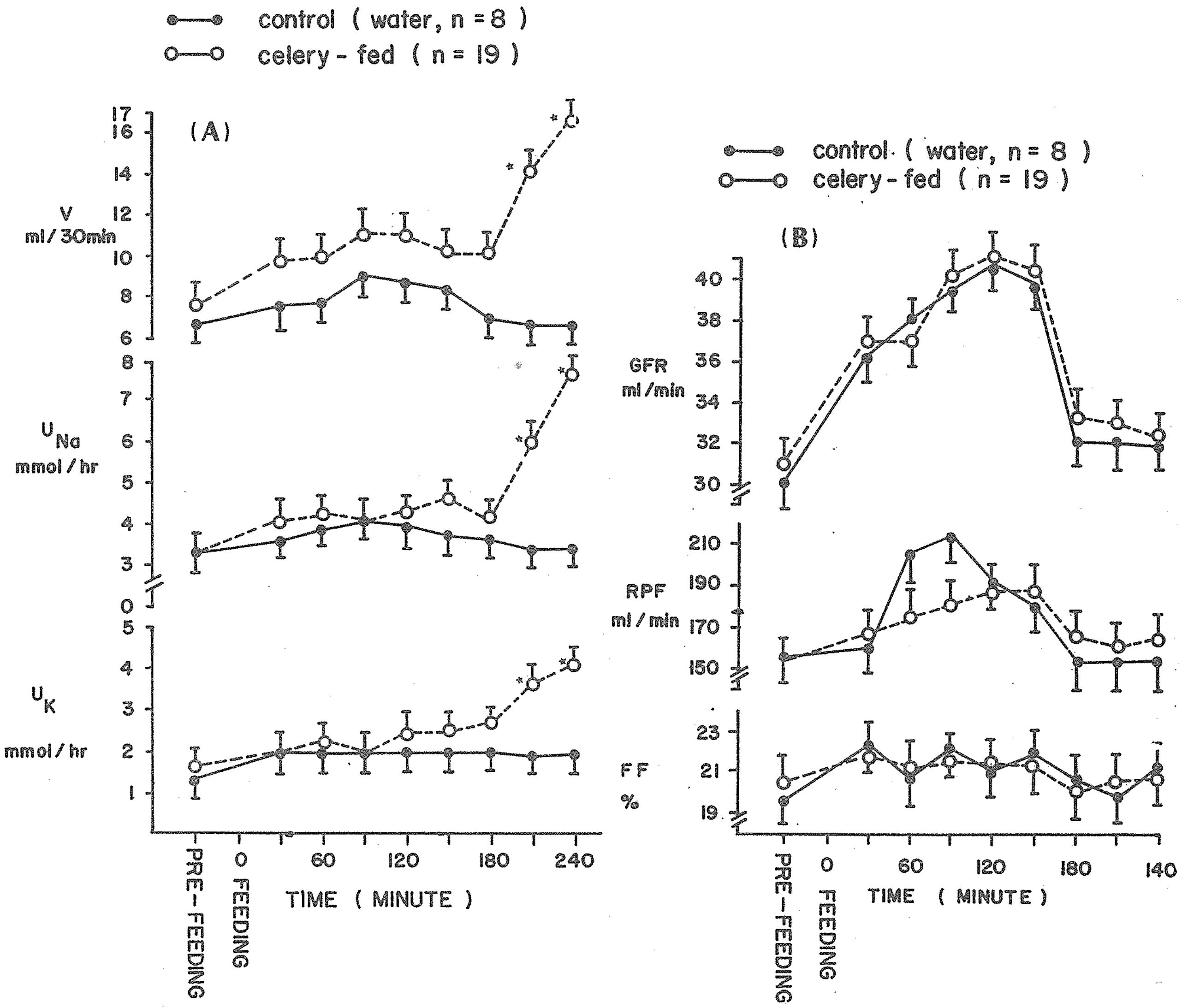

Figure 1. (a) Urine volume (V), sodium excretion (U_{Na}) and potassium excretion (U_K); (b) glomerular filtration rate (GFR), renal plasma flow (RPF) and filtration fraction in control (o, water-fed) and celery-fed (●) dogs. Asterisks indicate significant differences between the two groups at $P < 0.05$

Electrolyte composition of the celery extract

The celery decoction was also analyzed for its electrolyte composition. The result was as followed:

Na^+	169 mmol/L	Mg^{2+}	1.6 mmol/L
K^+	156 mmol/L	Ca^{2+}	152 mg/dl
Cl^-	632 mmol/L	P	38 mg/dl

The mongrel dogs used in the present study weighed 8.5 to 18 kg. with an average weight of 12.6 kg. Each dog, on the average received 252 ml of decoction was partly composed of Na^+ 43 mmol, K^+ 39 mmol, Cl^- 159 mmol, Mg^{2+} 0.4 mmol, P 96 mg and Ca^{2+} 383 mg.

DISCUSSION

Enteral administration of celery decoction was shown to be effective as an antihypertensive agent both in a high renin state or renal artery occlusion (Baramee & Lohsiriwat, 1987) and a low renin state or DOCA-salt hypertension (Itsarama-thangkurn et al., 1987). The antihypertensive mechanism has not yet been clearly identified though at least the anti-renin mechanism was excluded (Baramee & Lohsiriwat, 1987). The diuretic effect of celery was not related to the antihypertensive effect, since in both hypertensive models studied the blood pressure decreased within 30 to 60 min after celery feeding while diuresis took more than two h to show up.

In the present study, diuresis started three h after celery feeding without affecting blood pressure significantly in normotensive dogs. It seems that, in a normotensive state, celery does not produce significant hypotension within three h after celery administration, though celery decoction of the same dosage has been shown to be antihypertensive in different hypertensive models. This study again confirmed that the diuretic effect of celery was independent upon its effect on blood pressure.

The diuresis reported in this study was not caused by plasma volume expansion though a considerable volume of decoction was given. In the control group (water fed instead of celery), water diuresis commenced within 30 min and ended before three h. But the diuresis caused by celery began in the fourth h with much a larger urine volume, more than double, compared to the water diuresis. During celery-induced diuresis, no elevation of RPF, GFR, and filtration fraction occurred. The mechanism of diuresis was not dependent upon changes in glomerular function but was probably associated with the inhibition of tubular reabsorption. Urine sodium and urine potassium excretions also rose significantly by the time pronounced celery diuresis occurred.

Serum sodium and potassium increased gradually after the dogs were fed a celery decoction. This might be due to the high amount of sodium and potassium contained in the vegetable as shown at the end of our Results. The considerable amount of calcium as well as some other substances in the decoction might also play a role in the alteration of either cardiovascular or renal function.

It could be concluded from the present study that celery did not produce hypotension in normotensive dogs though it did decrease blood pressure in the hypertensive state. In other words, celery showed an antihypertensive effect but not a hypotensive one. Also, celery was shown to cause late-onset diuresis most likely resulting from a decrease in renal tubular sodium and potassium reabsorption without affecting the GFR or RPF. The experiment might be useful to those who favour the use of local and inexpensive medicinal plants. Celery can be recommended for hypertensive patients as an adjuvant treatment. However, they have to be reminded that the vegetable contains a considerable amount of potassium which is hazardous to patients with end-stage renal diseases. The temporary antifertility effect of celery (Visutakul et al., 1979) should also be considered.

REFERENCES

Baramee, J., & Lohsiriwat, S. (1987) The antihypertensive effect of celery in renovascular occlusive dogs. *Siriraj Hops. Gaz.* 39, 253-257.

Brun, C. (1951) A ripid method for the determination of para-amino hippuric acid in kidney function tests. *J. Lab. Clin. Med.* 37, 955-958.

Chulakarat, P., & Kolatat, T. (1978) The mechanism of hypotensive action of koenchai (Chinese celery). *J. Pharm. Ass. Thailand* 32, 97-105. (In Thai).

Isaramathangkurn, P., & Lohsiriwat, S. (1987) Antihypertensive effect of Chinese celery in DOCA-salt hypertensive dogs. Princess Congress I. Abstracts p. 63. *International Congress on Natural Products.* 10-13 December 1987, Bangkok, Thailand.

Kulshrestha, V.K., Singh, N., Saxena, R.C., & Kohli, R.P. (1970) A study of central pharmacological activity of alkaloid fraction of *Apium graveolens* Linn. *Indian J. Med. Res.* 58, 99-102.

Limpinuntana, C., & Chai-arj, P. (1977) Hypotensive effect of the extract of *Apium graveolens* Linn. *Mahidol Univ. Pharm. Sci.* 4, 10-13.

Maunwongyathi, P. (1981) Handbook of Medicinal Plant Application. *Madical Media Co., Bangkok* (In Thai).

Pachotikarn, J., Siriwongs, P. & Pugaman, P. (1976) Preliminary study in hypotensive activity of celery. *Chulalongkorn Med. J.* 20, 185-192.

Shiengthong, D., Uaprasert, V., Praruggamo, S., Siriwongs, P., & Pachotikarn, C. (1979) The organic constituents of celery. *Rep. Sci. Res.* 4, 177-193.

Tantiwat, P. (1978) *Madicinal Plants.* Chulalongkorn University Press, Bangkok. (In Thai).

Visutakul, P., Morakonpoon, P., Vanthanapong, R., & Cheungcharoen, D. (1979). Effect of koen-chai or Chinese celery *(Apium graveolens)* on spermatogenesis. *J. Med. Ass. Thailand.* 52, 164-170.

บทคัดย่อ

คณะผู้รายงานได้ทำการศึกษาผลของน้ำสกัดขึ้นฉ่ายในการขับปัสสาวะ ต่อไต อัตราการกรองที่ไต ปริมาณเลือดเลี้ยงไต และต่อความดันโลหิต โดยศึกษาในสุนัขที่ฉีดยาให้สลบแล้วกรอกน้ำสกัดขึ้นฉ่าย ทางสายยางจากปากสู่กระเพาะอาหาร ให้น้ำสกัดขึ้นฉ่าย 20 มล. ต่อน้ำหนักตัว 1 กิโลกรัมในสุนัข 19 ตัว เป็นกลุ่มทดลอง และกรอกน้ำกลั่นคิดปริมาตรเช่นเดียวกันให้สุนัขอีกแปดตัวเป็นกลุ่มควบคุมเพื่อเปรียบเทียบ พบว่าภายหลังการกรอกน้ำขึ้นฉ่ายหรือน้ำกลั่น ปริมาณปัสสาวะเพิ่มขึ้นไล่เลี่ยกันทั้งสองกลุ่มใน 3 ชั่วโมงแรก แต่ภายหลัง 3 ชั่วโมง กลุ่มที่ได้น้ำขึ้นฉ่ายมีการขับปัสสาวะออกมากชัดเจน มีการขับโซเดียมและโปแตสเซียมออกมาในปัสสาวะมากกว่ากลุ่มที่ได้น้ำกลั่น ในขณะที่อัตราการกรองของไต (คิดจากอัตราการชำระครีอาตินิน) ปริมาณเลือดเลี้ยงไต (คิดจากอัตราการชำระพาราอะมิโนฮิปปูเรท) และความดันโลหิตในสัตว์ทดลองทั้งสองกลุ่มไม่แตกต่างกัน

การศึกษาครั้งนี้แสดงว่าขึ้นฉ่ายขับปัสสาวะได้ แต่ออกฤทธิ์ช้าแสดงผลหลังจากกินขึ้นฉ่ายไปแล้ว 3 ชั่วโมง โดยไม่เปลี่ยนแปลงอัตราการกรองที่ไตหรือปริมาณเลือดเลี้ยงไต จึงน่าจะเกี่ยวข้องกับการดูดกลับเกลือและน้ำที่หลอดไต นอกจากนี้ยังพบว่าขึ้นฉ่ายไม่ทำให้ความดันโลหิตลดลงในสุนัขทดลองที่มีความดันโลหิตปกติ