EFFECT OF SINGLE-ADMINISTRATION CAPTOPRIL ON PLASMA AND URINARY VASOPRESSIN IN NORMOTENSIVE SUBJECTS AND PATIENTS WITH ESSENTIAL HYPERTENSION AND PRIMARY ALDOSTERONISM

TAKUYA TSUCHIHASHI, M.D., SHUICHI TAKISHITA, M.D., HIROMI MURATANI, M.D.
MICHIO UENO, M.D., YUJI TOMITA, M.D., YORIO KIMURA, M.D.
YAE NAKAO, M.D., AND MASATOSHI FUJISHIMA, M.D.

Effects of a single administration of captopril on plasma and urinary vasopressin (AVP) were examined in 8 normotensive (NT) female volunteers, 17 patients with essential hypertension (EHT) and 2 patients with primary aldosteronism (PA). Orally-administered captopril (25 mg) had no effect on plasma AVP levels in the three groups. However, urinary excretion of AVP decreased significantly after use of captopril in both NT and EHT subjects (-57% and -67% , respectively), and also in PA subjects. The magnitude of reduction in urinary AVP was significantly correlated with the pretreatment levels of plasma renin activity ($r = 0.85$) and plasma aldosterone concentration ($r = 0.88$) in NT subjects. Such correlation was not found in EHT subjects.

These results suggest that captopril decreases AVP secretion in both normotensive and hypertensive subjects, but the relation of the magnitude in AVP reduction by captopril to the peripheral renin-angiotensin system might be different.

ARGININE vasopressin (AVP) and renin-angiotensin (R-A) systems are known to play an important role in cardiovascular regulation. Angiotensin II (AII) stimulates AVP secretion in man¹ as well as in animals^{2,3} while AVP inhibits renin secretion in conscious animals⁴ suggesting some interaction of AVP and R-A systems.⁵ To clarify the relationship between these two systems, many investigators have examined the effect of converting enzyme inhibitor (CEI) on AVP in hypertensive sub-

jects⁶⁻⁸ and animal models,⁹⁻¹² but the results were equivocal and conflicting probably because of the differences in duration of CEI administration, level of blood pressure and status of the R-A system.

In order to investigate the influence of the R-A system inhibition on AVP, we examined the effects of a single administration of captopril on plasma and urinary AVP in normotensive subjects and in patients with essential hypertension or primary aldosteronism as well.

Key words:

Vasopressin
Captopril
Blood pressure
Renin-angiotensin system

SUBJECTS AND METHODS

Subjects included 8 normotensive (NT) volunteers (all women, 20.4 ± 0.2 years old), 17

(Received January 10, 1989; accepted May 19, 1989)

Second Department of Internal Medicine, Faculty of Medicine, Kyushu University, Fukuoka, Japan

Mailing address: Takuya Tsuchihashi, M.D., The Second Department of Internal Medicine, Faculty of Medicine, Kyushu University, Maidashi 3-1-1, Higashi-ku, Fukuoka City 812, Japan

TABLE I CHANGES IN BLOOD PRESSURE AND PULSE RATE BY CAPTOPRIL

	NT			EHT		
	Before	60 min	120 min	Before	60 min	120 min
SBP (mmHg)	101 ± 3	98 ± 4	101 ± 4	136 ± 5 ^{††}	126 ± 5 ^{**}	129 ± 5 [*]
DBP (mmHg)	61 ± 2	52 ± 3 ^{**}	53 ± 3 ^{**}	97 ± 5 ^{††}	88 ± 5 ^{**}	92 ± 4 [*]
PR (bpm)	56 ± 2	58 ± 4	57 ± 4	63 ± 2 [†]	63 ± 2	65 ± 3

Values are means ± SEM, NT = Normotension; EHT = Essential hypertension; SBP = Systolic blood pressure; DBP = Diastolic blood pressure; PR = Pulse rate

p* < 0.05 *p* < 0.01 vs Before, [†]*p* < 0.05 ^{††}*p* < 0.01 vs NT

TABLE II CHANGES IN SERUM ELECTROLYTES, CREATININE, OSMOLALITY, AVP, PRA AND PAC BY CAPTOPRIL

	NT		EHT	
	Before	After	Before	After
Na (mEq/L)	141.1 ± 0.6	140.8 ± 0.5	142.3 ± 0.7	142.1 ± 0.7
K (mEq/L)	4.0 ± 0.1	4.0 ± 0.1	4.4 ± 0.1 [†]	4.3 ± 0.1
Cr (mg/dl)	0.64 ± 0.03	0.64 ± 0.04	0.83 ± 0.04 [†]	0.83 ± 0.04
Osm (mOsm/kg)	290.4 ± 1.1	289.1 ± 1.0	289.9 ± 1.5	288.5 ± 1.3
AVP (pg/ml)	1.7 ± 0.3	1.9 ± 0.4	0.8 ± 0.1 ^{††}	0.9 ± 0.1
PRA (ng/ml/hr)	1.7 ± 0.6	12.3 ± 7.5	4.4 ± 1.4	33.6 ± 14.2 [*]
PAC (ng/dl)	9.6 ± 1.0	9.2 ± 0.6	11.8 ± 1.0	10.7 ± 0.9

Values are means ± SEM, NT = Normotension; EHT = Essential hypertension; Cr = Serum creatinine; Osm = Osmolality; AVP = Vasopressin; PRA = Plasma renin activity; PAC = Plasma aldosterone concentration

**p* < 0.05 vs Before, [†]*p* < 0.05 ^{††}*p* < 0.01 vs NT

patients (13 men and 4 women, 37.4 ± 1.9 y.o.) with essential hypertension (EHT) and 2 patients (both women, 38 and 46 y.o.) with primary aldosteronism (PA). The average blood pressure values in NT, EHT and PA subjects were 97/60, 160/105 and 157/91 mmHg, respectively. The purpose and detailed procedures of the protocol were explained and written consent was obtained. NT volunteers had no abnormalities upon physical examination, electrocardiogram, blood cell count and blood chemistry. In each patient with EHT, a careful examination was performed to rule out secondary hypertension. Left ventricular hypertrophy upon electrocardiography was observed in 5 of the 17 with EHT, but organ damage was not evident in the remaining 12 with EHT. In 2 cases of PA, adrenal adenoma was confirmed surgically.

Subjects were hospitalized and given a diet containing 8–10g of NaCl per day. In hypertensive patients, antihypertensive drugs were discontinued for at least 1 week prior to the study. After an overnight restriction of food

and water intake, the following protocol was conducted. After urinating at 8:00 am, subjects drank 100 ml of water and remained recumbent until 10:00 am (control period). Blood pressure and pulse rates were measured every 15 min from 8:00–9:30 am, and every 5 min thereafter. The average values of the last three measurements of blood pressure and pulse rates were taken as the control. At 10:00 am, venous samples were taken to determine plasma AVP, renin activity (PRA), aldosterone concentration (PAC), electrolytes, creatinine and osmolality. After the urine was collected to measure electrolytes, creatinine, AVP, osmolality, norepinephrine (NE), epinephrine (E) and dopamine (DA), 25 mg of captopril was administered orally with 100 ml of water. Thereafter, each subject remained recumbent and blood pressure and pulse rates were measured every 15 min. At 12:00 pm, blood and urine samples were taken again.

At the same time on a different day, the investigation was repeated without blood sampling on all NT subjects, and 5 EHT and 2 PA patients

TABLE III CHANGES IN URINARY PARAMETERS BY CAPTOPRIL

	NT		EHT	
	Before	After	Before	After
Urine volume (ml/2hrs)	129 ± 29	166 ± 59	107 ± 16	111 ± 18
Na (mEq/2hrs)	16.2 ± 2.3	16.3 ± 4.3	10.1 ± 1.1 [†]	11.4 ± 1.6
K (mEq/2hrs)	4.9 ± 0.6	4.5 ± 0.6	5.3 ± 0.4	4.8 ± 0.4
Cr (mg/2hrs)	129 ± 16	89 ± 5*	144 ± 13	130 ± 9
Osmolality (mOsm/kg)	732 ± 137	643 ± 131*	699 ± 61	649 ± 60
AVP (pg/mg creatinine)	37.6 ± 8.2	13.4 ± 2.8**	20.4 ± 3.5 [†]	6.2 ± 1.2**
NE (μg/2hrs)	2.6 ± 0.6	1.6 ± 0.2	2.2 ± 0.5	2.4 ± 0.6
E (μg/2hrs)	0.87 ± 0.21	0.59 ± 0.14	0.69 ± 0.15	1.06 ± 0.28
DA (μg/2hrs)	41.6 ± 7.5	28.4 ± 3.0	32.1 ± 3.6	30.7 ± 6.2

Values are means ± SEM, NT = Normotension; EHT = Essential hypertension; Cr = Creatinine; AVP = Vasopressin; NE = Norepinephrine; E = Epinephrine; DA = Dopamine

* $p < 0.05$ ** $p < 0.01$ vs Before, [†] $p < 0.05$ vs NT

Fig.1. Percent change in urinary AVP excretion by captopril or placebo administration in NT (left) and EHT (right) subjects.

who received a placebo instead of captopril.

Venous blood was collected in ice-cooled tubes which contained EDTA-2Na for AVP and PRA, and heparin-Na for PAC determination. The plasma was rapidly separated by refrigerated centrifugation. The plasma and urine samples were stored at -20°C until assay.

Blood pressure was measured with a sphygmomanometer. Serum and urinary concentrations of electrolytes were measured by flame photometry, creatinine by kinetic assay (Beckman II, USA) and osmolality using the freezing point method.

PRA¹³ and PAC¹⁴ were determined by radioimmunoassay, and urinary NE, E and DA were measured by high performance liquid chromatography and by native fluorescence.¹⁵ Plasma and urinary AVP were assayed using an Arginine Vasopressin kit (Immunonuclear Corporation, USA).¹⁶ EDTA plasma and urine samples were acidified with 1N HCl. AVP was then extracted with octadecasil silica (Sep Pak, C₁₈ Cartridges, Water Associates, USA) and measured by radioimmunoassay. When 2 ml of plasma was extracted, the least-detectable concentration was

Fig. 2. Correlation between pretreatment level of plasma renin activity and percent change in urinary AVP excretion by captopril in NT (upper) and in EHT (lower) subjects.

0.6 pg/ml. Within-assay variabilities of plasma and urinary AVP were 5.6% and 8.2%, respectively. Between-assay variability of AVP was 12.8% for plasma and 12.1% for urine, and mean recovery of added AVP was 97.3% and 83.5%, respectively. All samples for a given individual were measured simultaneously in the same assay system for each parameter.

All results are expressed as the mean $\pm$ SEM. Statistical analysis was performed using the Student's *t*-test for paired and unpaired samples.

RESULTS

Changes in blood pressure and pulse rate by captopril are shown in Table I. Systolic blood pressure in EHT subjects and diastolic blood pressure in both NT and EHT subjects were decreased significantly by captopril, whereas there was no change in pulse rate in both groups. In PA subjects, however, blood pressure and pulse rate did not change with captopril. The

percent change in mean blood pressure (60 min) was inversely correlated with the basal value of log PRA in both NT ($r = -0.74$, $p < 0.05$) and EHT subjects ($r = -0.67$, $p < 0.01$). In contrast, the placebo produced no significant changes in blood pressure or pulse rate in all three groups. Serum electrolytes, creatinine and osmolality remained unchanged following captopril in NT and EHT groups (Table II). The basal value of plasma AVP was significantly lower in EHT than in NT subjects, although plasma AVP changed little with captopril in each group. PRA increased with captopril in both groups, but its change was significant only in EHT subjects. PAC in both groups did not change with captopril. In PA subjects, basal values of PRA were suppressed to below 0.2 ng/ml/hr and PAC was elevated (29.3 and 24.9 ng/dl), which were not affected by captopril.

Urinary parameters were evaluated by comparing 2 hours of urine collection before and after captopril (Table III). Urine volume, electro-

Fig.3. Correlation between pretreatment level of plasma aldosterone concentration and percent change in urinary AVP excretion by captopril in NT (upper) and in EHT (lower) subjects.

lyte excretion and catecholamines were unaffected by captopril. Urinary excretion of AVP, which is analyzed using a creatinine-adjusted value because of the significant reduction in urinary creatinine by captopril in NT subjects, was lower in EHT than NT at rest and decreased significantly to 57% of the baseline in NT and 67% in EHT subjects following captopril. A similar degree of reduction in urinary AVP was also observed in 2 PA subjects (57% and 73%). Placebo administration also led to a 27% reduction of urinary AVP excretion in NT and 24% in EHT, although such reductions were significantly greater with captopril than with the placebo in both groups (Fig. 1).

The correlations between percent change in urinary AVP and pretreatment levels of PRA and PAC are shown in Figs. 2 and 3. In NT subjects, percent change in urinary AVP was inversely correlated with PRA ($r = -0.85$, $p < 0.01$) and PAC as well ($r = -0.88$, $p < 0.01$). Such relationships, however, were not demonstrated in EHT subjects. These data indicate that the reduction

in urinary AVP by captopril is related to the status of the peripheral R-A system only in NT subjects.

DISCUSSION

The influence of the R-A system on AVP has been investigated exclusively by means of AII or CEI administration. It is clear that central AII causes AVP secretion in animals.^{17,18} The evidence that peripheral angiotensin stimulates AVP secretion, however, is controversial.¹⁹ Some investigators have shown an increase in AVP secretion by intravenous infusion of AII in dogs and rats,^{2,3} whereas others have failed.^{10,20} Phillips et al found increased AVP secretion by intravenous AII infusion in 4 of 10 healthy young men studied.¹ Since plasma AII concentration achieved by AII infusion is beyond physiological range, it is difficult to define whether the effect of AII is physiological or not.

The effect of captopril administration has also been investigated in humans as well as in animals.

Captopril treatment for 3 to 8 days reduces plasma and/or urinary AVP in patients with severe hypertension, although the effects on the first day of treatment remain controversial.⁶⁻⁸ In patients with congestive heart failure, the elevated plasma AVP was not affected by captopril.^{21,22} Plasma AVP was also unaffected by captopril in rats or in other animals,¹⁰⁻¹² whereas urinary AVP fell during the development of hypertension in spontaneously hypertensive rats.⁹

In the present study, single oral administration of captopril reduced urinary excretion of AVP, while no change in plasma AVP was observed. As urinary excretion of AVP is considered to be a more useful indicator of endogenous AVP secretion than plasma concentration in man,^{16,23} these results may suggest that captopril reduced AVP secretion. This phenomenon occurred regardless of blood pressure level or status of the R-A system. One possible mechanism that could be responsible for the inhibition of AVP secretion by captopril is a reduction in the plasma AII concentration. This mechanism, however, does not seem to be applicable in this study because a similar degree of reduction in urinary AVP was observed in some EHT patients with relatively low PRA (see Fig. 2) and in PA patients. The other speculative hypothesis is that captopril acts centrally to inhibit AVP secretion. As to the central effect of captopril, recent studies have demonstrated that intracerebroventricular administration of captopril reduces plasma AVP concentration or AVP response to hemorrhagic stress in established DOCA-salt hypertensive rats²⁴ or in sheep.²⁵ There is some evidence that the pressor or dipsogenic effect of centrally administered angiotensin I is inhibited by oral administration of captopril.^{26,27} More recently, a single oral administration of captopril had been shown to inhibit angiotensin-converting enzyme activity in human cerebrospinal fluid.²⁸ Therefore, it might be possible that oral captopril in the present study reduced AVP secretion by inhibiting the central R-A system. Although the central R-A system is considered to be independent of the peripheral R-A system,²⁹ the relationship between both systems in various conditions is not well known. As the reduction in urinary AVP by captopril was significantly correlated with pretreatment levels of PRA in NT and not in EHT subjects, this unidentified mechanism might be reflected in the peripheral R-A system only in NT subjects. In addition to the difference in

blood pressure levels, however, the possibility that the difference in age and sex between the groups could modify the AVP response to captopril should also be considered. Furthermore, captopril might influence renal tubular reabsorption, secretion or degradation of AVP to reduce urinary AVP excretion. We, however, cannot differentiate the decreased secretion from the change in renal handling of AVP as a cause of the reduction in urinary AVP by captopril in this study.

Finally, basal values of plasma and urinary AVP were higher in NT than in EHT subjects. Whether or not plasma AVP is elevated in human hypertension is still a matter of debate. Some investigators have shown an elevated plasma AVP in EHT subjects,^{30,31} but others have demonstrated normal or even lowered plasma AVP in EHT subjects.³²⁻³⁴ It might be undesirable to compare NT and EHT groups in this study as there were differences in age and sex. However, considering previous studies demonstrating higher AVP in the elderly^{35,36} and in men,³⁷ NT subjects investigated in the present study might have had the lower AVP values because they were all female and younger than EHT subjects. Therefore, the difference between the groups might be attributed to the level of blood pressure, although other factors affecting AVP secretion must be considered.

In conclusion, the present study demonstrated that a single administration of captopril reduced AVP secretion in NT subjects, and also in patients with EHT and PA. Captopril's exact mechanism of action in reducing AVP secretion remains undetermined.

Acknowledgments

We would like to thank S. Nakamuta, K. Inutsuka and M. Mihara for their valuable technical assistance.

REFERENCES

1. PHILLIPS PA, ROLLS BJ, LEDINGHAM JGG, MORTON JJ, FORSLING ML: Angiotensin II-induced thirst and vasopressin release in man. *Clin Sci* 68: 669, 1985
2. RAMSAY DJ, KEIL LC, SHARPE MC, SHISAKO J: Angiotensin II infusion increases vasopressin, ACTH, and 11-hydroxycorticosteroid secretion. *Am J Physiol* 234: R66, 1978
3. KNEPEL W, BEUERS U, NUTTO D, HERTTING G: Effect of captopril (SQ14225) on vasopressin release induced by angiotensin in the conscious rat. *Clin Sci* 62: 341, 1982
4. SCHWARTZ J, REID IA: Role of the vasoconstrictor and antidiuretic activities of vasopressin in

- inhibition of renin secretion in conscious dogs. *Am J Physiol* 250: F92, 1986
5. SHARE L: Interrelations between vasopressin and the renin-angiotensin system. *Federation Proc* 38: 2267, 1979
 6. THIBONNIER M, ALDIGIER JC, SOTO ME, SASANO P, MENARD J, CORVOL P: Abnormalities and drug-induced alterations of vasopressin in human hypertension. *Clin Sci* 61: 149s, 1981
 7. THIBONNIER M, SOTO ME, MENARD J, ALDIGIER JC, CORVOL P, MILLIEZ P: Reduction of plasma and urinary vasopressin during treatment of severe hypertension by captopril. *Eur J Clin Invest* 11: 449, 1981
 8. ALDIGIER JC, PLOUIN PF, GUYENE TT, THIBONNIER M, CORVOL P, MENARD J: Comparison of the hormonal and renal effects of captopril in severe essential and renovascular hypertension. *Am J Cardiol* 49: 1447, 1982
 9. CROFTON JT, SHARE L, HOROVITZ ZP: The effect of SQ14225 on systolic blood pressure and urinary excretion of vasopressin in the developing spontaneously hypertensive rat. *Hypertension* 1: 462, 1979
 10. BRUNNER DB, BURNIER M, BRUNNER HR: Plasma vasopressin in rats. Effect of sodium, angiotensin, and catecholamines. *Am J Physiol* 244: H259, 1983
 11. BEN LK, MASELLI J, KEIL LC, REID IA: Role of the renin-angiotensin system in the control of vasopressin and ACTH secretion during the development of renal hypertension in dogs. *Hypertension* 6: 35, 1984
 12. OLSSON K, FYHRQUIST F, BENLAMLITH S, DAHLBORN K: Effects of captopril on arterial blood pressure, plasma renin activity and vasopressin concentration in sodium-repleted and sodium-deficient goats. *Acta Physiol Scand* 121: 73, 1984
 13. HABER E, KOERNER T, PAGE LB, KLIMAN B, PURNODE A: Application of a radioimmunoassay for angiotensin I to the physiologic measurements of plasma renin activity in normal human subjects. *J Clin Endocrinol Metab* 29: 1349, 1969
 14. NAKAMUTA S, MURATANI H, TOMITA Y, TAKISHITA S, FUJISHIMA M, UEZONO K, KAWASAKI T: Plasma aldosterone concentration in patients with primary aldosteronism during the last decade. *Folia Endocrinol Japon* 61: 1221, 1985
 15. KAWANO Y, FUKIYAMA K: Determination of urinary catecholamines using high-performance liquid chromatography and native fluorescence measurements. *Fukuoka Acta Med* 71: 625, 1980
 16. MOSES AM, STECIAK E: Urinary and metabolic clearances of arginine vasopressin in normal subjects. *Am J Physiol* 251: R365, 1986
 17. MOUW D, BONJOUR JP, MALVIN RL, VANDER A: Central action of angiotensin in stimulating ADH release. *Am J Physiol* 220: 239, 1971
 18. KEIL LC, SUMMY-LONG J, SEVERS WB: Release of vasopressin by angiotensin II. *Endocrinology* 96: 1063, 1975
 19. PHILLIPS MI: Functions of angiotensin in the central nervous system. *Ann Rev Physiol* 49: 413, 1987
 20. REID LA, BROOKS VL, RUDOLPH CD, KEIL LC: Analysis of the actions of angiotensin on the central nervous system of conscious dogs. *Am J Physiol* 243: R82, 1982
 21. STANEK B, BRUCKNER U, SILBERBAUER K: Plasma vasopressin as influenced by acute and chronic blockade of the renin-angiotensin system. *J Hypertens* 3: S-129, 1985
 22. RIEGGER GAJ, KOCHSIEK K: Vasopressin, renin and norepinephrine levels before and after captopril administration in patients with congestive heart failure due to idiopathic dilated cardiomyopathy. *Am J Cardiol* 58: 300, 1986
 23. KJELDSEN SE, OS I, FORSBERG G, AAKESSON I, SKJØTØ J, FREDERICHSEN P, FØNSTELIEN E, EIDE I: Dietary sodium intake increases vasopressin secretion in man. *J Clin Hypertens* 1: 123, 1985
 24. ITAYA Y, SUZUKI H, MATSUKAWA S, KONDO K, SARUTA T: Central renin-angiotensin system and the pathogenesis of DOCA-salt hypertension in rats. *Am J Physiol* 251: H261, 1986
 25. CAMERON VA, ESPINER EA, NICHOLLS MG, MACFARLANE MR, SADLER WA: Intra-cerebroventricular captopril reduces plasma ACTH and vasopressin responses to hemorrhagic stress. *Life Sci* 38: 553, 1986
 26. EVERED MD, ROBINSON MM, RICHARDSON MA: Captopril given intracerebroventricular, subcutaneously or by gavage inhibits angiotensin-converting enzyme activity in the rat brain. *Eur J Pharmacol* 68: 443, 1980
 27. MARSON O, RIBEIRO AB, TUFIC S, KOHLMANN O, RAMOS OL: Inhibition of central angiotensin I conversion by oral captopril. *Brazilian J Med Biol Res* 14: 73, 1981
 28. GEPETTI P, SPILLANTINI MG, FRILLI S, PIETRINI U, FANCIULLACCI M, SICUTERI F: Acute oral captopril inhibits angiotensin converting enzyme activity in human cerebrospinal fluid. *J Hypertens* 5: 151, 1987
 29. GANONG WF: The brain renin-angiotensin system. *Ann Rev Physiol* 46: 17, 1985
 30. COWLEY AW, CUSHMAN WC, QUILLEN EW, SKELTON MM, LANGFORD HG: Vasopressin elevation in essential hypertension and increased responsiveness to sodium intake. *Hypertension* 3 (Suppl 1): I-93, 1981
 31. OS I, KJELDSEN SE, SKJØTØ J, WESTHEIM A, LANDE K, AAKESSON I, FREDERICHSEN P, LEREN P, HJERMANN I, EIDE IK: Increased plasma vasopressin in low renin essential hypertension. *Hypertension* 8: 506, 1986
 32. PADFIELD PL, BROWN JJ, LEVER AF, MORTON JJ, ROBERTSON JIS: Changes of vasopressin in hypertension: cause or effect? *Lancet* 1: 1255, 1976
 33. DAVIES R, FORSLING M, BULGER G, PHILLIPS T: Plasma vasopressin and blood pressure. Studies in normal subjects and in benign essential hypertension at rest and after postural challenge. *Br Heart J* 49: 528, 1983
 34. JOHNSTON CI: Vasopressin in circulatory control and hypertension. *J Hypertens* 3: 557, 1985
 35. FROLKIS VV, GOLOVCHENKO SF, MEDVED VI, FROLKIS RA: Vasopressin and cardiovascular

- system in aging. *Gerontology* **28**: 290, 1982
36. OS I, KJELDSEN SE, AAKESSON I, SKJØTT J, EIDE I, HJERMANN I, LEREN P: Evidence of age-related variation in plasma vasopressin of normotensive men. *Scand J Clin Lab Invest* **45**: 263, 1985
37. CROFTON JT, DUSTAN H, SHARE L, BROOKS DP: Vasopressin secretion in normotensive black and white men and women on normal and low sodium diets. *J Endocr* **108**: 191, 1986