

Regulation of plasma aldosterone during hemodialysis

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ABSTRACT: *In order to clarify the influence of serum potassium, serum sodium and plasma angiotensin II concentrations on aldosterone release during hemodialysis (HD), six chronic hemodialysis patients were studied during HD with varying dialysate sodium concentrations and different buffers. Plasma aldosterone concentrations were higher during acetate than bicarbonate HD, during low sodium compared to high sodium HD, and were correlated inversely to serum sodium concentrations. The decline in plasma aldosterone concentrations during HD paralleled the decrease in serum potassium concentrations, and plasma aldosterone concentrations were correlated with serum potassium concentrations. In addition, plasma aldosterone and plasma angiotensin II concentrations were correlated significantly. It is proposed that serum potassium and the renin-angiotensin system are the main factors of aldosterone release during hemodialysis, while serum sodium per se seems to be of less importance. The dialysate buffer employed also plays a role in aldosterone regulation (via the renin-angiotensin system) (Int J Artif Organs 1990; 13: 32-8).*

KEY WORDS: *Hemodialysis, Aldosterone regulation, Angiotensin II*

INTRODUCTION

The regulation of aldosterone secretion has been the subject of various studies (1-3; reviews of literature) and serum potassium, angiotensin II and serum sodium concentrations, with ACTH, are widely accepted as the main factors regulating aldosterone secretion both in normal subjects and patients with end-stage renal disease. Rises in plasma angiotensin II and serum potassium concentrations, and plasma ACTH, and decreases in serum sodium concentrations and plasma volume are known to stimulate aldosterone secretion. The major transduction mechanisms are activation of phospholipase C, activation of adenylate cyclase, calcium influx and calcium release (3).

The aim of the present study was to investigate the relationship between plasma aldosterone and serum potassium, serum sodium, and plasma angiotensin II concentrations in relation to different dialysate sodium concentrations and dialysate buffers during hemodialysis (HD).

PATIENTS AND METHODS

Six patients with end-stage renal disease were examined during a regular 4 h acetate HD at one of four dialysate sodium concentrations (135, 140, 145, 150 mmol/l) and five of those patients during bicarbonate HD at the same four dialysate sodium concentrations (each patient was studied at one of the four dialysate sodium concentrations). In each case a HD procedure using the same protocol with regard to buffer and dialysate sodium concentration was performed two days before the HD procedure included in our study.

The mean age of the patients was 46.2 years (17-66), and they had been on chronic HD treatment for 2.7 years (0.5-7.0); the etiology of the renal failure was polycystic kidneys, pyelonephritis or hydronephrosis. No patient was bilaterally nephrectomized, and none received antihypertensive treatment.

Blood samples were obtained from the arterial line, before dialysis, after 80 min, after 160 min, and after

4 h of dialysis and concentrations of aldosterone and angiotensin II were measured by commercially available kits (Fa. H. Biermann Medizinische Systeme GmbH, Bad Nauheim, FRG; Coat-A-Count Aldosteron and J-125 Angiotensin II). Sodium and potassium concentrations were measured with ion-selective electrodes (Nova 1, Nova Biomedical GmbH, Darmstadt, FRG). Hormone and electrolyte concentrations were corrected for hemoconcentrations, using hematocrit as a measure.

Dialysate was prepared using dialysate preparations (PGS 22 (Fa. Fresenius AG, Bad Homburg, FRG) and 8.4 % NaHCO_3 for bicarbonate dialysis, Y108 (Fa. B. Braun, Melsungen, FRG) for acetate dialysis and dialysate sodium and potassium concentrations were checked by direct measurements. Final dialysate concentrations were: potassium 2.0-2.2 mmol/l; sodium 135, 140, 145, 150 mmol/l; bicarbonate 31-35 mmol/l (+ 3 mmol/l acetate); acetate 35-39 mmol/l.

The HD procedure was as follows: 4 h three times per week, blood flow 250 ml/min, dialysate flow 444 ml/min (Cobe Centry 2000 Rx, Cobe Laboratories GmbH, Kirchheim, FRG); dialyser: 1.4 m^2 surface, saponified cellulose ester (C-DAK Artificial Kidney 135 sce, CD Medical GmbH, München, FRG).

Statistical analysis was done by Student's paired t-test and the correlation coefficient. P values < 0.05 were considered statistically significant and data are given as mean \pm SEM.

RESULTS

Angiotensin II concentration was 90.0 ± 9.9 pg/ml ($n = 96$) during acetate HD and 28.9 ± 1.7 pg/ml ($n = 80$) during bicarbonate HD ($p < 0.0001$; range of normal values 5-15 pg/ml; 63.6 ± 10.8 pg/ml for all values obtained during either acetate or bicarbonate HD). Angiotensin II concentrations at different dialysate sodium concentrations during acetate or bicarbonate dialysis are set out in Figure 1 and were significantly higher ($p < 0.001$) during acetate than bicarbonate HD at 135 and 140 mmol/l, lower during bicarbonate than acetate HD at 150 mmol/l ($p < 0.001$).

Angiotensin II concentrations during the course of acetate and bicarbonate HD are shown in Figure 2. Aldosterone concentration was 573 ± 60 pg/ml ($n =$

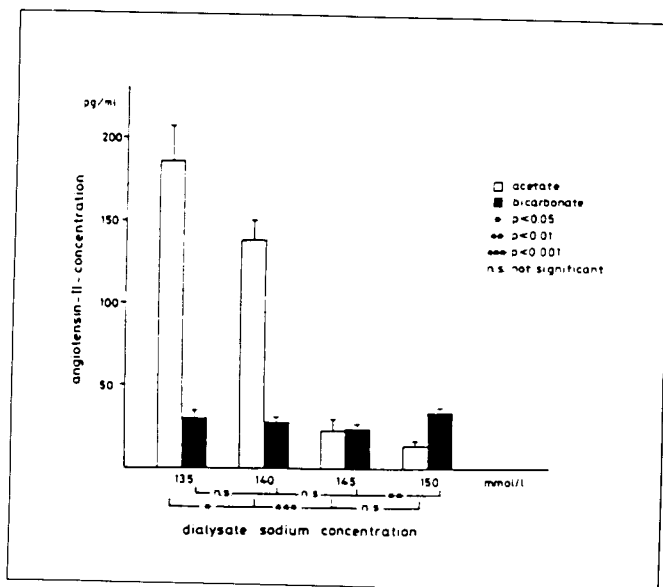


Fig. 1 - Plasma angiotensin concentrations during hemodialysis with acetate or bicarbonate at different dialysate sodium concentrations (means \pm SEM of all values obtained at all time points at a given dialysate sodium concentration and a given buffer).

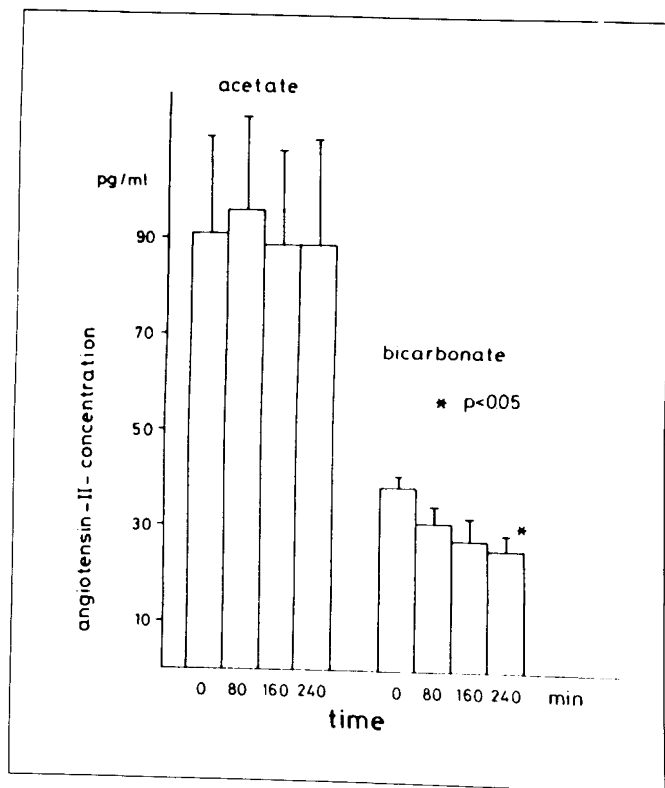


Fig. 2 - Plasma angiotensin concentrations at four time points during acetate or bicarbonate hemodialysis (means \pm SEM of all values obtained at all four dialysate sodium concentrations).

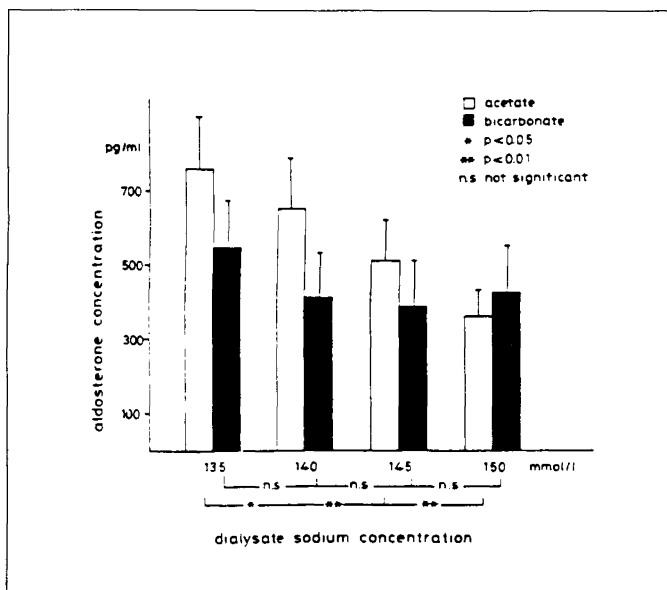


Fig. 3 - Plasma aldosterone concentrations during hemodialysis with acetate or bicarbonate at different dialysate sodium concentrations (means \pm SEM of all values obtained at all time points).

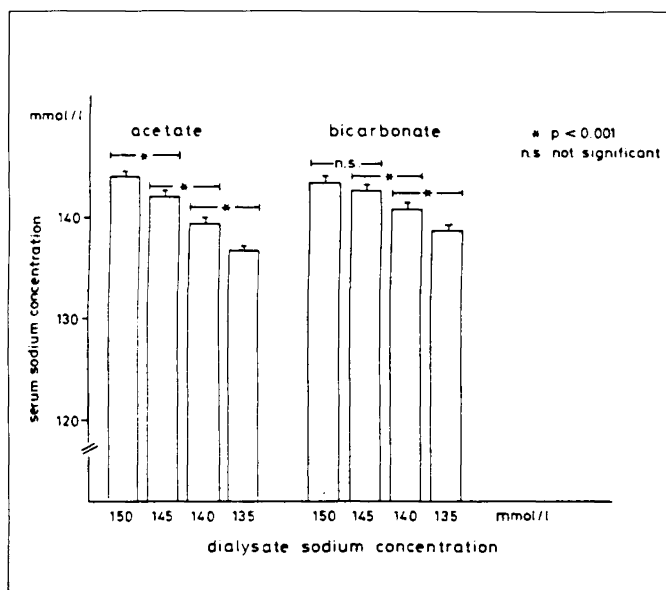


Fig. 5 - Serum sodium concentrations during hemodialysis with acetate or bicarbonate at different dialysate sodium concentrations (means \pm SEM at all time points).

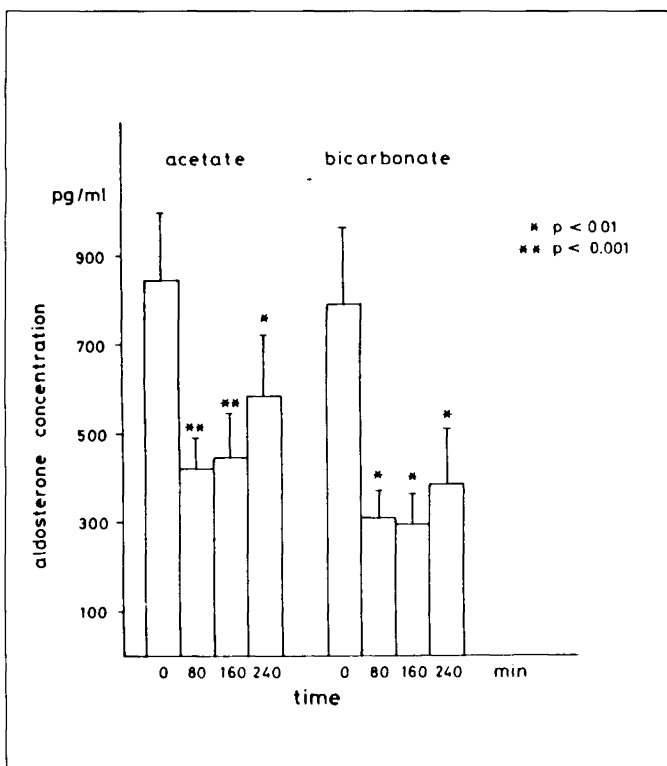


Fig. 4 - Plasma aldosterone concentrations at four time points during acetate or bicarbonate hemodialysis (means \pm SEM at all dialysate sodium concentrations).

96) during acetate HD and 446 ± 62 pg/ml ($n = 80$) during bicarbonate HD ($p < 0.05$; range of normal values 10-160 pg/ml; 509 ± 74 pg/ml for all values obtained during acetate or bicarbonate HD).

Figures 3 and 4 give aldosterone concentrations at different dialysate sodium concentrations and dialysate buffers, and during the course of dialysis. Plasma aldosterone was significantly higher during HD at 140 mmol/l ($p < 0.05$) and at 145 mmol/l ($p < 0.01$) with acetate than with bicarbonate; the differences were not significant at 135 and 150 mmol/l. Serum sodium concentrations were higher at high than at low dialysate sodium concentrations, during both bicarbonate and acetate HD (Fig. 5).

Serum sodium concentration decreased during acetate HD at low dialysate concentrations and increased during bicarbonate HD at 150 mmol/l dialysate sodium concentration (Figs. 6 and 7). The decreases in serum potassium concentrations were very similar during dialysis with both dialysate buffers (Figs. 8 and 9). Despite these results small but significant differences were observed in serum potassium concentration at low compared to high dialysate sodium concentrations (Fig. 10).

Angiotensin II concentration was correlated nega-

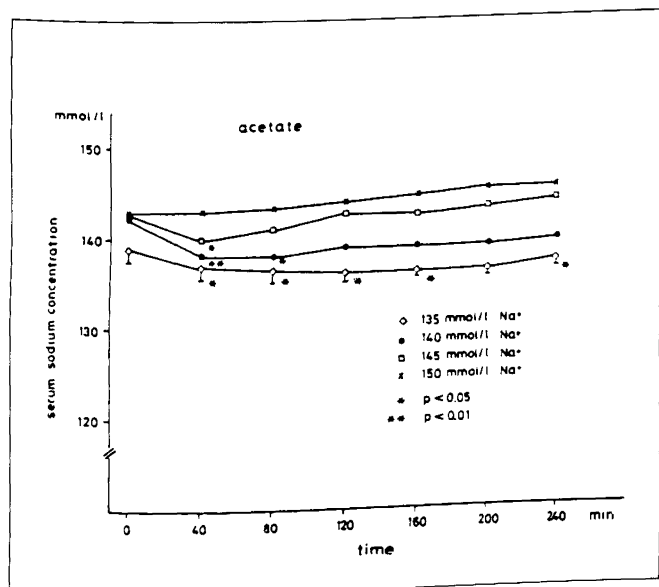


Fig. 6 - Serum sodium concentrations during acetate hemodialysis at different dialysate sodium concentrations (means; for reasons of legibility SEM is only given at 135 mmol/l dialysate sodium concentration).

tively with serum sodium concentration ($p < 0.01$) during acetate but not during bicarbonate dialysis. Angiotensin II concentration was also correlated positively ($p < 0.01$) with aldosterone concentration during HD with both dialysate buffers. Aldosterone during HD was correlated positively to serum potassium concentration ($p < 0.01$) and negatively to serum sodium concentration ($p < 0.01$) during acetate or bicarbonate dialysis.

Mean volume removal was nearly identical during acetate and bicarbonate HD (2.15 L/2.10 L).

DISCUSSION

Serum aldosterone is elevated in most patients with end-stage renal disease. It is dependent on serum potassium/dialysate potassium during HD, although there are some contradictory data, whereas little information is available on aldosterone regulation during hemodialysis with different dialysate buffers (2, 4-19).

This study, like others, found elevated serum aldosterone concentrations. Serum aldosterone was higher during acetate than during bicarbonate HD. It was also higher during low-sodium than high-sodium HD, when acetate not bicarbonate was employed. These

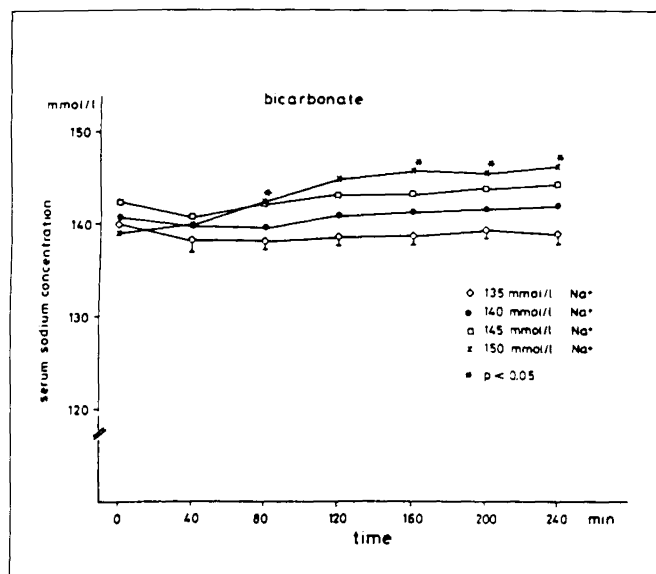


Fig. 7 - Serum sodium concentrations during bicarbonate hemodialysis at different dialysate sodium concentrations (means; for reasons of legibility SEM is only given at 135 mmol/l dialysate sodium concentration).

buffer-related differences in aldosterone concentrations cannot be explained by differences in serum potassium concentrations. The slightly higher serum potassium concentrations during high-sodium hemodialysis might be due to minute differences in dialysate potassium concentrations, although serum potassium decreased in a parallel manner at all dialysate sodium concentrations (Figs. 8 and 9). If those differences in serum potassium concentrations exert any effect at all on aldosterone concentration, then serum aldosterone concentrations ought to be higher during high-sodium (associated with slightly higher serum potassium concentrations) than during low-sodium HD, thus possibly reducing a real difference.

The decrease in aldosterone concentration during hemodialysis with either acetate or bicarbonate and the positive correlation between serum potassium and plasma aldosterone concentrations confirm the major role of potassium for aldosterone regulation in patients with end-stage renal disease. These data are in accordance with most Authors (2, 8-10, 13, 15-19, 23), but disagree with the results of Ratge et al. (14). The loss of aldosterone across the dialyser membrane during hemodialysis seems to be of little importance (10).

Serum sodium concentration, a known factor in aldosterone regulation (1-3), shows no major diffe-

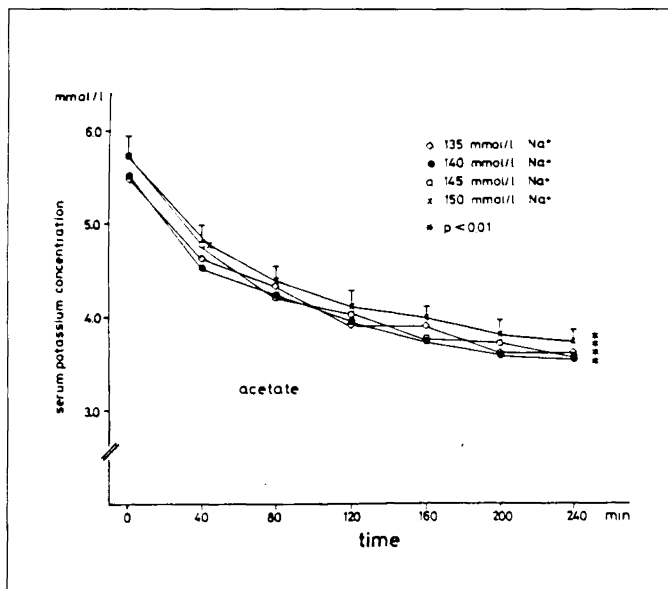


Fig. 8 - Serum potassium concentrations during acetate hemodialysis at different dialysate sodium concentrations (means; for reasons of legibility SEM is only given at 150 mmol/l dialysate sodium concentration).

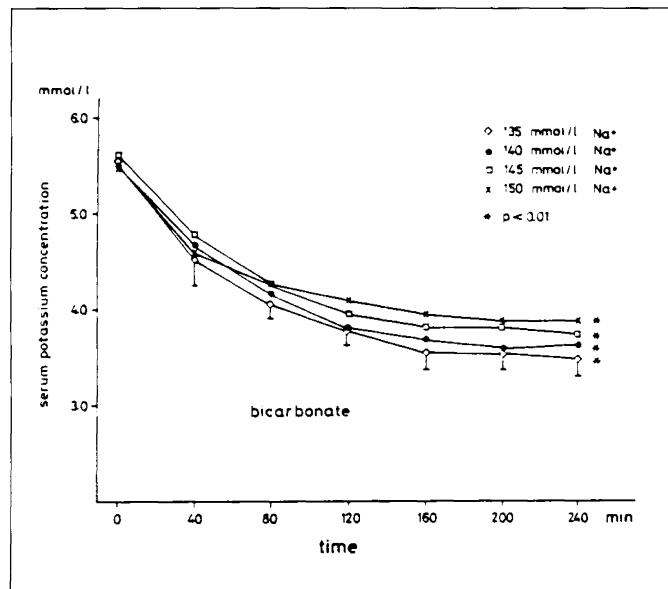


Fig. 9 - Serum potassium concentrations during bicarbonate hemodialysis at different dialysate sodium concentrations (means; for reasons of legibility SEM is only given at 145 mmol/l dialysate sodium concentration).

rences during HD with different buffers and it thus probably has no effect on aldosterone release in different ways during acetate and bicarbonate HD. However, using the same dialysate buffer, plasma aldosterone concentration was higher during low-sodium than during high-sodium acetate HD (with insignificant differences during bicarbonate HD). A correlation between serum sodium and plasma aldosterone concentrations was shown during HD with either acetate or bicarbonate, thus confirming the known effects of serum sodium concentration on aldosterone release (1, 2, 16, 20).

Besides serum potassium and serum sodium concentrations, angiotensin II is a major aldosterone regulating factor (1-3). During acetate but not during bicarbonate HD the angiotensin II concentration was higher at low than at higher dialysate sodium concentrations. In addition the angiotensin II concentration was higher with low-sodium acetate HD than low-sodium bicarbonate HD; this provides an explanation of the buffer-related differences in plasma aldosterone concentrations. However, there is no explanation for the rather high angiotensin II concentration during bicarbonate HD at 150 mmol/l. The

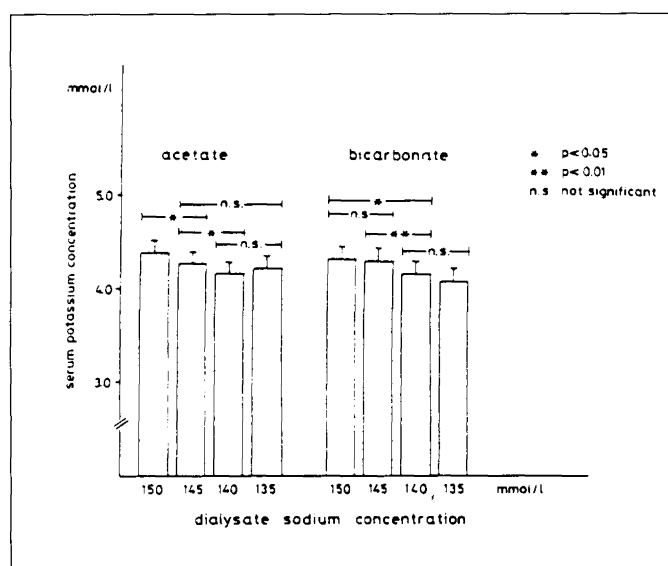


Fig. 10 - Serum potassium concentrations during hemodialysis with acetate or bicarbonate at different dialysate sodium concentrations (means \pm SEM at all time points).

decrease in angiotensin II concentration seen during bicarbonate HD was not observed during acetate HD and this provides further support for the assumption that angiotensin II formation rates are higher during

acetate than bicarbonate HD. The higher rate of stimulation of the renin-angiotensin-aldosterone system is probably secondary to the vasodilating effect of acetate (11; discussion of literature) and the slower refilling of plasma volume during acetate HD (21).

Greater plasma renin activity during acetate than bicarbonate HD, an actual increase of plasma renin activity during acetate but not during bicarbonate HD (11), and more stable blood pressure regulation during bicarbonate HD (12) have all been demonstrated. Igarashi et al. (22) have shown elevated angiotensin II concentrations before and during HD in hypertensive patients on chronic HD. The differences in predialytic angiotensin II concentrations before acetate and bicarbonate HD are thought to be due to the

different dialysate buffers in chronically treated patients, although the role of dialysate sodium concentration and buffers on the interdialytic renin-angiotensin-aldosterone system were not investigated in the present study. Further studies are necessary to clarify the roles of different dialysate buffers in relation to different dialysate sodium concentrations on interdialytic regulation of the renin-angiotensin-aldosterone system.

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