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Research Article

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ABSTRACT In recent studies in this laboratory employing normal hydropenic rats we have demonstrated that the reduction in absolute proximal reabsorption that attends the experimental reduction of single nephron glomerular filtration rate (SNGFR) (glomerulotubular balance) is mediated, at least in part, by the accompanying decline in postglomerular vascular protein concentration, and therefore, postglomerular colloid osmotic pressure (π_{EA}). The present study was undertaken to define the quantitative contribution of these changes in π_{EA} to the changes in absolute proximal reabsorption measured under these conditions. A protocol was employed which enabled us to examine the effects on absolute proximal reabsorption of reductions in filtered load brought about under conditions in which π_{EA} remained essentially unchanged. Thus, after partial aortic constriction in 16 plasma-loaded rats, near constancy of π_{EA} was observed in 10 (a change in efferent arteriolar protein concentration of 0.4 g/100 ml or less) and in these, uniform reductions in SNGFR averaging 16.7 nl/min were attended by reductions in absolute proximal reabsorption averaging only 1.7 nl/min, or 7% of preconstriction values. These findings, taken together with previous observations from this laboratory, suggest that the proximal reabsorptive adjustment that characterizes glomerulotubular balance in the rat is markedly blunted when changes in π_{EA} are prevented. In the remaining six rats, a mean reduction in filtered load comparable to that observed in the above group was attended by slightly to moderately greater reductions in efferent arteriolar protein concentration, thereby fulfilling less well the stated aim of this study. Nevertheless, in accord with the above conclusion, these relatively greater reductions in π_{EA} were accompanied by correspondingly greater reductions in absolute proximal reabsorption.

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INTRODUCTION

Recent observations in the rat and rabbit have led workers to suggest that fluid reabsorption by the renal proximal tubule is regulated to an important extent by factors extrinsic to the tubule epithelium (1–5). Evidence of a causal nature has been provided thus far for only one factor, namely postglomerular colloid osmotic pressure (π_{EA}) (6, 7).[1] To ascertain the quantitative extent to which changes in π_{EA} contribute to changes in absolute proximal reabsorption, two well-described experimental phenomena have been studied in the rat. In examining the mechanism of inhibition in proximal sodium reabsorption that takes place in response to acute expansion of extracellular volume with colloid-free solutions, we observed, using capillary microperfusion techniques, that this inhibition could be largely (e.g., 70–80%) but usu-

[1] *Abbreviations used in this paper:* $\overline{AP}$, mean femoral arterial pressure; π, colloid osmotic pressure; π_{EA}, postglomerular colloid osmotic pressure; $[Protein]_{EA}$, protein concentrations in efferent arteriolar blood plasma; $[Protein]_{FA}$, protein concentrations in femoral arterial blood plasma; SNFF, single nephron filtration fraction; SNGFR, single nephron glomerular filtration rate; $(TF/P)_{IN}$, tubule fluid/plasma inulin ratio; V_{TF}, volume of tubule fluid.

ally not completely reversed by selective restoration of π_{EA} alone to preexpansion levels (7). Whether failure to completely reverse this inhibition with return of π_{EA} to normal levels was the consequence of limitations imposed by the capillary microperfusion technique or whether other extrinsic and/or intrinsic factors also contribute to this depression in reabsorption, we compared the effects on reabsorption of systemic infusions of isoncotic vs. colloid-free solutions (8). For rats expanded with isoncotic plasma, neither average reductions in π_{EA} nor absolute proximal reabsorption were observed whereas after equivalent volume expansion with colloid-free Ringer's solution, highly significant and parallel reductions in reabsorption and π_{EA} obtained. These findings were interpreted as providing little experimental support for the action of factors other than π_{EA} in mediating the observed inhibition in proximal reabsorption after colloid-free infusions.

The second phenomenon studied by us was the more or less proportional reduction in absolute proximal reabsorption that takes place in response to acute reductions in glomerular filtration rate (glomerulotubular balance); this is a phenomenon (9) which, in the normal hydropenic rat, is also attended by reductions in π_{EA} (6, 10). Again employing capillary microperfusion techniques, selective restoration of π_{EA} alone from below normal to normal levels in kidneys with reduced filtration rates resulted in parallel increases in absolute proximal reabsorption (6). While these findings provide strong evidence for a governing role for changes in π_{EA} in mediating these adjustments in reabsorption, it was again noted that restoration of π_{EA} to control levels was not regularly associated with a return of reabsorption fully to control, but only, on average, to some 50–60% of base-line values. Needed then to differentiate between technical limitations and the action of factor(s) other than π_{EA} in mediating these changes in reabsorption is an experimental setting in which reductions in filtered load can be achieved in the absence of accompanying reductions in π_{EA}. In a recent examination of the hemodynamic determinants of autoregulation of glomerular ultrafiltration (11), we observed that whereas in normal hydropenia, π_{EA} and filtration rate regularly declined in response to reductions in mean femoral arterial pressure ($\overline{AP}$) from levels of roughly 120–80 mm Hg, in rats preexpanded with isoncotic plasma (2.5% body weight), similar reductions in $\overline{AP}$ resulted in corresponding reductions in filtered load but little, if any, changes in π_{EA}.[2]

This response of cortical nephrons in plasma loaded rats to reductions in $\overline{AP}$ thus provides the desired experimental setting outlined above. Accordingly, the present study was undertaken to examine the influence of acute reductions in filtered load on proximal reabsorption in plasma loaded rats.

METHODS

Adult Sprague-Dawley ($n = 8$) and Munich-Wistar ($n = 8$) rats ranging in weight from 260–340 g and allowed free access to food and water were anesthetized with Inactin (Promonta, Hamburg, West Germany) (100 mg/kg) and prepared for micropuncture as described previously (6, 12, 13). Beginning 120 min before micropuncture each rat received the intravenous infusion of a volume of homologous rat plasma (obtained by arterial exsanguination of a litter mate on the morning of study) equal to 2.5% body weight administered in a period of 90 min. 60 min before micropuncture, an isotonic NaCl infusion was begun at the rate of 0.02 ml/min. This solution contained inulin in a concentration of 10%, thereby resulting in final plasma concentrations of about 100 mg/100 ml. $\overline{AP}$ was monitored by means of an electronic transducer (Model P23AA, Statham Instruments, Inc., Oxnard, Calif.) connected to a direct-writing recorder (Model 7702B, Hewlett-Packard Co., Palo Alto, Calif.). Late surface convolutions of proximal tubules were located by observing the passage of Lissamine green dye which was injected rapidly (0.05 ml of a 5% solution) into a right jugular vein catheter. After this 60 min equilibration period, exactly timed (1–2 min) samples of fluid were collected from each experimental tubule for determination of flow rate and inulin concentration, and calculation of single nephron glomerular filtration rate (SNGFR). The rate of fluid collection was adjusted to maintain a column of polymer oil (Kel F polymer oil, Minnesota Mining and Manufacturing Co., 3M Center, St. Paul, Minn.), 3–4 tubule diameters in length, in a relatively constant position just distal to the site of puncture. Using the collection technique of controlled suction recently validated for this laboratory (13, 14), minimal changes in tubule diameter or the position of the distal oil block were produced. Coincident with these tubule fluid collections, femoral arterial blood samples were obtained for determination of hematocrit and plasma inulin concentration.

To estimate colloid osmotic pressure (π) of systemic and postglomerular plasma, protein concentrations in femoral arterial ($[\text{Protein}]_{FA}$) and efferent arteriolar ($[\text{Protein}]_{EA}$) blood plasmas were measured as described previously (15). π was calculated from the equation for plasma derived by Landis and Pappenheimer (16) and recently validated for the rat (17). These estimates of $[\text{Protein}]_{FA}$ and $[\text{Protein}]_{EA}$ also permit calculation of single nephron filtration fraction (SNFF).

After measurements at normal renal perfusion pressures, mean arterial perfusion pressures to the left (experimental) kidney was reduced by means of partial constriction of the abdominal aorta.This was achieved by applying tension to a fine silk ligature encircling the abdominal aorta between the origins of the renal arteries, as outlined in detail elsewhere (9). After partial aortic constriction, determinations of tubule fluid flow rate and inulin concentration and $[\text{Protein}]_{FA}$ and $[\text{Protein}]_{EA}$ were repeated for each rat. The recollection micropuncture technique was employed in reassessing proximal tubule function, whereas separate efferent arterioles were punctured for the repeat determination of $[\text{Protein}]_{EA}$. The length of time required to obtain

[2] The hemodynamic basis for the differing effects of reductions in $\overline{AP}$ on π_{EA} in normal hydropenia and plasma-loaded rats is considered in detail elsewhere (11).

the necessary measurements and collections never exceeded 30 min at each level of $\overline{AP}$.

Analytical. The volume of tubule fluid collected from individual proximal tubules was estimated from the length of the fluid column in a constant bore capillary tube of known internal diameter. The concentration of inulin in tubule fluid was measured, nearly always in duplicate, by the microfluorescence method of Vurek and Pegram (18). Inulin concentrations in urine and plasma were determined using the macro-anthrone method of Führ, Kaczmarczyk, and Krüttgen (19). $[Protein]_{FA}$ and $[Protein]_{EA}$ were determined, usually in duplicate, with an ultramicro-colorimeter using a recently described microadaptation (15) of the technique of Lowry, Rosebrough, Farr, and Randall (20).

Calculations. SNGFR was calculated from the tubule fluid/plasma inulin $[(TF/P)_{IN}]$ ratio and volume of tubule fluid (V_{TF}) collected per min by means of the expression:

$$SNGFR = (TF/P)_{IN} \cdot V_{TF}, \quad (1)$$

The absolute rate of tubule fluid reabsorption to the site of puncture was calculated as the difference between SNGFR and V_{TF}.

The fraction of the filtered volume reabsorbed to the site of nephron puncture was calculated using the expression:

$$\text{Fractional reabsorption} = 1 - \left(\frac{\text{plasma}}{\text{tubule fluid}}\right)_{IN}, \quad (2)$$

SNFF was estimated from simultaneous measurements of $[Protein]_{FA}$ and $[Protein]_{EA}$ using the expression:

$$SNFF = 1 - \frac{[Protein]_{FA}}{[Protein]_{EA}}, \quad (3)$$

Student's *t* test was employed in the statistical analysis of all results.

RESULTS

Although aortic constriction resulted in a reduction in filtered load in each rat, relative constancy of π_{EA} did not always obtain. We therefore elected to divide experimental results into two groups, depending on whether $[Protein]_{EA}$ remained essentially constant (group I) or declined (group II). Included in group I are the results from 10 rats in which $[Protein]_{EA}$ declined by no more than 0.4 g/100ml. In view of this small change,[3] these rats have been taken to satisfy the aim of this study. In the remaining six rats (group II), $[Protein]_{EA}$ declined by more than 0.4 g/100ml. This choice of a change of 0.4 g/100ml as the basis for assigning rats to one or the other group is arbitrary, and as will become apparent, is of minor importance in that the individual data for rats in both groups have been subjected to an examination of the relationship between changes in absolute proximal reabsorption and changes in $[Protein]_{EA}$. To further insure against bias in this division of data, a blind protocol was employed in which the separate operation of analyzing tubule fluid samples for determinations of proximal reabsorptive function and pre- and postglomerular plasma samples for determinations of $[Protein]_{FA}$ and $[Protein]_{EA}$ were performed by different individuals, each prevented from knowing the other's results until after all data had been recorded and calculations completed.

Individual and mean values for proximal nephron function and pre- and postglomerular protein concentration obtained before aortic constriction in these plasma loaded rats are given in the left-hand panels of Tables I (for group I rats) and II (for group II rats). Mean values for each of the measured and calculated quantities tended to agree closely between groups, and to correspond to values previously reported (8, 11, 21).

Partial aortic constriction resulted in reductions in renal perfusion pressure to comparable levels in groups I and II (Tables I and II). Proximal $(TF/P)_{IN}$ ratios increased in nearly every tubule (Tables I and II), with recollection/initial collection ratios averaging 1.33 $\pm$0.07 SE ($P < 0.001$) and 1.21$\pm$0.05 ($P < 0.005$) for groups I and II, respectively. Accordingly, proximal fractional reabsorption increased an average of 35.6% $\pm$5.3 ($P < 0.001$) in group I and 23.1$\pm$6.6 ($P < 0.005$) in group II.

Aortic constriction resulted in uniform reductions in SNGFR. While the average decrements were very nearly the same for groups I and II (Fig. 1), SNGFR tended to remain higher in group I than II (Tables I and II). We observed little or no change in $[Protein]_{FA}$ (Tables I and II) or systemic hematocrit (mean = 40.0%$\pm$0.8 before, and 39.7%$\pm$0.9 during aortic constriction in group I and 40.3%$\pm$0.8 and 39.9%$\pm$0.9, respectively, in group II) over the course of these experiments. Changes in $[Protein]_{EA}$, if any, in group I (Table I), and those in group II (Table II) therefore reflect primary reductions in cortical nephron filtration fraction, the determinants of which for these conditions have been described in detail elsewhere (11). For the 10 rats in group I, SNFF averaged 0.27$\pm$0.02 before aortic constriction, a value nearly identical to that reported previously (8, 11, 21). During aortic constriction SNFF remained unchanged in group I (mean = 0.27$\pm$0.02) with paired changes in individual rats ranging between $\pm$0.03 and averaging $-$0.005$\pm$0.006 ($P > 0.4$). For group II SNFF declined, on average, from 0.28$\pm$0.02 to 0.24$\pm$0.02, with paired changes ranging from $-$0.02 to $-$0.07 and averaging $-$0.05 $\pm$0.007 ($P < 0.001$). The resulting declines in π_{EA}, relative to preconstriction values (Fig. 1), averaged $-$1.1 $\pm$0.3 mm Hg ($P < 0.025$; range: + 0.7 to $-$2.5) and

[3] The sensitivity of the ultra-micro protein assay has been found in this and previous studies (6, 10) to be capable of discriminating among changes in concentration of 0.3 g/100 ml or greater.

TABLE I

Group I. Effects of Partial Aortic Constriction on Single Nephron Function in Plasma Expanded Rats in Which $[Protein]_{EA}$ Changed by 0.4g/100 ml or Less

	Plasma expanded rats—preconstriction						During aortic constriction (recollection)						
Exp. no	$\overline{AP}$	$(TF/P)_{IN}$ (i)	SNGFR	Absolute proximal reabsorptive rate to site of puncture	[Protein] FA	[Protein] EA	$\overline{AP}$	$(TF/P)_{IN}$ (r)	r/i	SNGFR	Absolute proximal reabsorptive rate to site of puncture	[Protein] FA	[Protein] EA
	mm Hg		*nl/min*	*nl/min*	*g/100 ml*		*mm Hg*			*nl/min*	*nl/min*	*g/100 ml*	
1	110	1.71	47.8	19.9	6.2	7.6	80	2.08	1.22	30.9	16.0	6.1	7.5
		1.55	55.3	19.7				2.45	1.58	33.5	19.8		
2	120	1.48	53.2	17.4	5.8	8.9	80	2.85	1.93	23.4	15.8	5.7	8.8
		1.68	51.1	20.7				3.88	2.31	28.1	20.8		
4	120	1.44	55.1	16.9	6.0	8.5	80	1.66	1.15	40.2	16.0	5.9	8.4
		1.39	56.2	15.7				1.60	1.15	40.0	15.1		
		1.51	46.0	15.6				1.89	1.25	33.3	15.7		
5	120	1.65	67.4	26.5	6.0	7.8	80	1.78	1.08	46.8	20.5	6.0	7.6
		1.79	60.7	26.8				1.71	0.96	51.1	21.2		
7	150	1.68	59.9	24.4	6.5	9.1	85	2.75	1.64	39.2	24.9	6.4	9.2
		1.90	61.0	28.8				2.59	1.36	38.1	23.4		
		1.75	59.5	25.5				3.17	1.81	38.6	26.4		
9	115	1.59	43.3	16.1	5.9	7.6	80	1.78	1.12	31.8	14.0	5.9	7.2
		1.48	43.0	14.1				1.58	1.07	30.6	11.2		
11	110	1.50	52.6	17.5	6.0	7.8	75	1.76	1.17	47.0	20.2	5.9	7.4
		1.74	55.0	23.4				1.88	1.08	46.0	21.6		
12	125	1.86	44.1	20.3	6.1	8.4	92	2.16	1.16	30.7	16.5	5.9	8.4
		1.68	43.2	17.5				2.09	1.24	41.5	21.7		
15	130	1.90	64.5	30.5	5.8	8.1	80	2.40	1.26	45.6	26.6	5.8	8.0
		1.85	70.7	32.5				2.35	1.27	lost	—		
16	125	1.54	64.7	22.8	5.9	9.6	80	1.93	1.25	39.9	19.2	5.8	9.3
		1.42	60.8	18.0				1.77	1.25	38.0	16.5		
Mean	122	1.64	55.2	21.4	6.0	8.3	81	2.19	1.33	37.8	19.2	5.9	8.2
±SE	3.7	0.03	1.7	1.1	0.1	0.2	1.4	0.12	0.07	1.6	0.9	0.1	0.2
Mean Δ from initial (%)								+35.6*		−30.2	−7.2	−1.3	−2.0
±SE								5.3		2.5	2.7	0.3	0.6
P value§								<0.001	<0.001‡	<0.001	<0.025	<0.005	<0.025

* Refers to mean change in proximal fractional reabsorption.
‡ Difference from unity.
§ Calculated for paired data using Student's *t* test.
r/i, recollection/initial collection $(TF/P)_{IN}$.

-4.5 ± 0.5 ($P < 0.001$; range: -3.3 to -6.1) in groups I and II, respectively.

Despite comparable reductions in $\overline{AP}$ and filtered load in groups I and II, absolute proximal reabsorption declined significantly less ($P < 0.001$), on average, in group I than group II. As shown for group I rats in Fig. 1 and Table I, the changes in absolute proximal reabsorption tended to be small, albeit significant ($P < 0.025$), averaging -1.7 nl/min±0.6, or $-7.2\pm2.7\%$ of preconstriction values. The relationship between changes in absolute proximal reabsorption and changes in π_{EA} in individual rats is examined in Fig. 2. For rats in group I (solid circles) the possibility exists that even these small declines in absolute proximal reabsorption may have been the result of the accompanying small, but significant ($P < 0.025$) declines in π_{EA}. In support of this possibility is our recent finding that reductions in $\overline{AP}$ of the magnitude induced in the present study fail to significantly alter peritubular capillary hydrostatic pressures (11). In group II the significantly greater declines in absolute proximal reabsorption (Table II and Fig. 1), averaging 5.1 nl/min±0.5 ($P < 0.001$) or $26.4\pm2.7\%$ of preconstriction values, tended to parallel the greater declines in π_{EA} (Fig. 2, open circles).

To further assess the interrelationships among changes in filtered load, π_{EA}, and absolute proximal reabsorption, Fig. 1 also depicts mean values recently obtained from normal hydropenic rats in response to partial aortic constriction. The results for these rats have been reported in detail elsewhere (6). In hydropenia, despite reductions in renal perfusion pressure

TABLE II

Group II. Effects of Partial Aortic Constriction on Single Nephron Function in Plasma Expanded Rats in Which [Protein]$_{EA}$ Declined by More Than 0.4g/100 ml

	Plasma expanded rats—preconstriction						During aortic constriction						
Exp. no	$\overline{AP}$	$(TF/P)_{IN}$ (i)	SNGFR	Absolute proximal reabsorptive rate to site of puncture	[Protein] FA	[Protein] EA	$\overline{AP}$	$(TF/P)_{IN}$ (r)	r/i	SNGFR	Absolute proximal reabsorptive rate to site of puncture	[Protein] FA	[Protein] EA
	mm Hg		*nl/min*	*nl/min*	*g/100 ml*		*mm Hg*			*nl/min*	*nl/min*	*g/100 ml*	
3	120	1.62	47.7	18.2	5.8	7.6	80	2.11	1.30	25.3	13.4	5.8	6.9
		2.09	47.0	24.5				2.56	1.22	25.2	15.3		
		2.32	44.1	25.1				2.82	1.22	25.7	16.6		
6	115	1.52	40.8	14.0	6.1	8.2	75	1.58	1.04	32.6	12.0	5.8	7.5
		1.52	39.3	13.5				1.69	1.11	22.3	9.1		
8	135	1.89	45.1	21.2	6.0	8.4	85	1.73	.92	37.8	16.0	5.7	7.5
		1.78	56.4	24.7				3.02	1.70	33.2	23.2		
10	135	1.98	45.3	22.5	6.0	8.9	95	2.08	1.05	31.4	16.3	5.9	8.0
		1.84	55.6	25.4				2.40	1.30	36.4	21.3		
13	120	1.35	38.7	10.1	5.8	8.6	80	1.64	1.21	19.7	7.7	5.6	8.1
		1.34	38.7	9.9				1.28	.96	24.6	5.4		
		1.60	40.0	15.0				1.82	1.14	25.3	11.4		
14	110	1.64	67.7	24.6	6.2	8.5	80	2.28	1.39	35.3	19.8	6.3	8.0
		1.44	66.0	20.2				1.96	1.36	29.4	14.4		
Mean	123	1.71	48.0	19.3	6.0	8.4	82	2.07	1.21	28.9	14.4	5.9	7.7
±SE	4.2	0.08	2.6	1.6	0.1	0.2	2.8	0.13	0.05	1.5	1.4	0.1	0.2
Mean Δ from initial (%)								+23.1*		−39.0	−26.4	−2.2	−8.2
±SE								6.6		2.9	2.7	1.1	0.9
P value								<0.005	<0.005‡	<0.001	<0.001	>0.05	<0.00

r/i recollection/initial collection $(TF/P)_{IN}$.

* Mean change in proximal fractional reabsorption.

‡ Difference from unity.

and SNGFR comparable in magnitude to that achieved in the present study, the decline in π_{EA} was greater, on average, than in groups I and II and was paralleled by a correspondingly greater average decline in absolute proximal reabsorption.

DISCUSSION

In recent years there has accumulated increasingly more convincing evidence for a direct relationship between π_{EA} and the absolute rate of fluid reabsorption by the rat proximal tubule (4, 6–8, 10, 12, 15, 22–24), a relationship presumably coupled by an effect of π_{EA} to influence the transcapillary exchange of isotonic reabsorbate (22). In view of this coupling, and recent evidence in the normal hydropenic rat that the parallel and more or less proportional reductions in absolute proximal reabsorption that take place in response to reductions in filtered load (glomerulotubular balance) are also attended by parallel declines in π_{EA} (6, 10), we have sought to determine the quantitative contribution of these changes in π_{EA} in mediating the reabsorptive adjustments observed under these conditions. In our initial study, in the normal hydropenic rat (6), absolute reabsorption in surface proximal tubules was estimated during partial aortic constriction, when renal perfusion pressure, SNGFR, and $[Protein]_{EA}$ were reduced below preconstriction levels. Then, with renal perfusion pressure and SNGFR maintained at these reduced levels, the postglomerular protein concentration in microvessels surrounding these test proximal tubules was restored to preconstriction levels, using selective capillary microperfusion techniques. During this dissociation of filtered load and π_{EA}, absolute proximal reabsorption increased in conjunction with this selective increase in π_{EA}, on average, to within 50–60% of preconstriction levels, thereby demonstrating that glomerulotubular balance is mediated, at least in part, by changes in π_{EA}. With regard to the quantity of absolute proximal reabsorption not restored to preconstriction levels by these maneuvers, two possibilities have been considered (6). One is that a factor or factors in addition to changes in π_{EA} also contribute to the proximal reabsorptive adjustment seen in glomerulotubular balance. The second, by no means exclusive of the first, is that technical limitations which unavoidably attend the use of the capillary microperfusion technique (these

have been identified in detail elsewhere [6]) may have led to systematic underestimates of the contribution of changes in π_{EA} to changes in proximal reabsorption. The protocol employed in the present study appears to have provided results which enable us to distinguish between these possibilities. Thus, in rats in which π_{EA} remained essentially unchanged, uniform reductions in SNGFR averaging 16.7 nl/min were attended by reductions in absolute proximal reabsorption averaging only 1.7 nl/min, or 7% of preconstriction values. We interpret these findings to indicate that the proximal reabsorptive adjustment which characterizes the phenomenon of glomerulotubular balance is primarily dependent upon hemodynamic adjustments which alter SNFF, and thereby, π_{EA}. When, as in group I rats, these hemodynamic adjustments fail to alter SNFF, and therefore π_{EA} (the explanation for the differing effects of partial aortic constriction on SNFF in normal hydropenia and plasma loaded rats has been examined in detail elsewhere [11]), glomerulotubular balance is essentially abolished, in that absolute proximal reabsorption remains remarkably insensitive to changes in filtered load. Under these conditions, then, proximal fractional reabsorption varies inversely with changes in filtered load (as shown in Fig. 1, for group I rats). Essentially these same conclusions have been reported by others using different experimental approaches (1–5, 8).

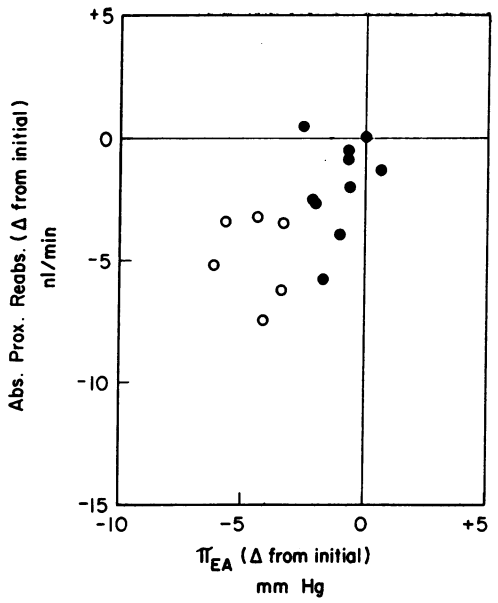

FIGURE 2 Relationship between changes in π_{EA} and changes in absolute proximal reabsorption for individual rats in groups I (solid circles) and II (open circles).

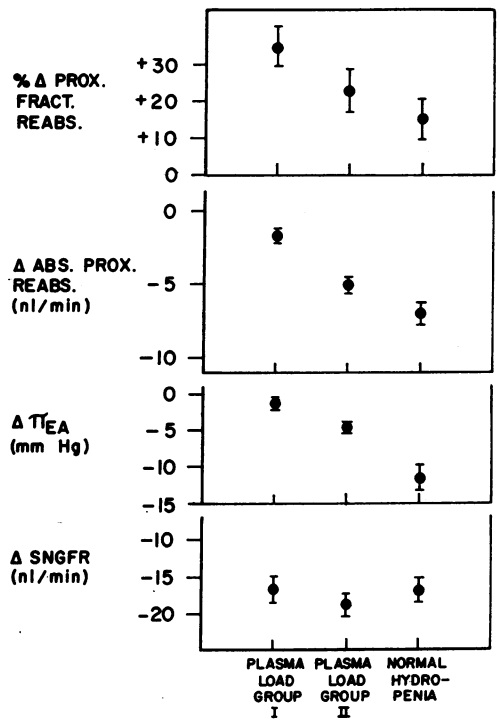

FIGURE 1 The effects of partial aortic constriction on the interrelationships among changes in proximal sodium reabsorption (absolute and fractional), π_{EA}, and SNGFR. Data for normal hydropenia have been reported in detail elsewhere (6).

That these conclusions are not critically dependent upon the arbitrary separation of the present data into groups I and II can be seen from an analysis of the combined data from both groups. For the total of 35 tubules examined in this study, the uniform decline in filtered load averaged 17.7 nl/min and was accompanied by an overall average decline in absolute proximal reabsorption of 2.9 nl/min±0.5, or only 14.9%±2.5 of preconstriction values.

Fig. 3 quantitates the relationship between π_{EA} and absolute proximal reabsorption in response to alterations in SNGFR induced by a variety of experimental maneuvers aimed at testing the glomerulotubular balance mechanism. Summarized here are the average values for these quantities for all studies reported to date (6, 10, present study) in which direct measurements of postglomerular vascular protein concentration and absolute proximal reabsorption have been obtained in the same experimental rats. Solid symbols denote the relationship between π_{EA} and absolute proximal reabsorption before a change in SNGFR, open symbols, this relationship in response to alterations in SNGFR. The slopes relating the changes in π_{EA} and absolute reabsorption are seen to be similar from group to group,

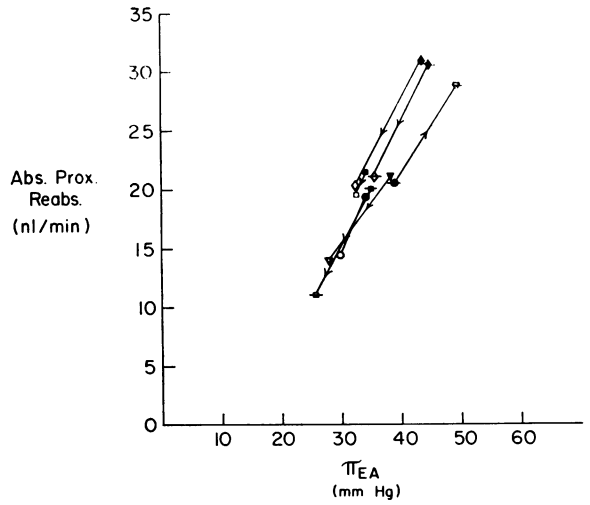

FIGURE 3 Assessment of the relationship between π_{EA} and absolute proximal reabsorption for a variety of conditions involving changes in SNGFR. Solid symbols denote values before alterations in SNGFR, open symbols, values during experimental alterations in SNGFR. Lines join mean values for each maneuver. Direction of change in SNGFR is indicated by arrows. The data from the present study are indicated by ■ (group I) and ● (group II). Symbols -◆-, -■-, and -●- denote experiments in normal hydropenic rats involving partial aortic constriction, renal venous occlusion, and bilateral carotid occlusion, respectively, and have been reported in detail elsewhere (10). A second series of partial aortic constriction experiments in normally hydropenic rats studied by the authors (6) is given by the symbol ▼. The symbol ◆ denotes rats in which acute hemorrhage was employed (1% body weight) to reduce SNGFR (Brenner and Troy, Unpublished observation).

irrespective of either the base-line value or direction of change in SNGFR. For all seven conditions currently available for analysis, the change in absolute proximal reabsorption per 10 mm Hg change in π_{EA} averages 2.4 nl/min·mm.[4]

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[4] Since all studies involved punctures of end-proximal segments, we have assumed a distance of 4 mm in the calculation of this value.

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