CHAPTER 77

Effect of Obstruction on Renal Function

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The decrease in renal function that may occur in association with benign prostatic hypertrophy (BPH) is due to chronic partial bilateral ureteral obstruction. When acute urinary retention occurs there is a superimposed element of acute ureteral obstruction. The change in renal function in this case is different from that of other acute obstructions of normal kidneys, e.g., that from stones or ureteral ligation.

In BPH preexistent hydronephrosis and resultant changes in renal function are usually well established at the time of onset of acute urinary retention. Therefore studies of the effects of acute ureteral obstruction in animal models are not comparable to what is happening to renal function in the older male with BPH. On the other hand, animal models that deal with the effects of bilateral chronic partial ureteral obstruction are helpful in understanding the basic renal pathophysiology associated with BPH. Similarly, because of the existence of renal counterbalance and compensatory hypertrophy, unilateral obstruction models are not particularly useful in understanding the decrease in renal function usually seen in association with BPH.

The incidence of impaired renal function in association with BPH has been reported to be 15–25% and is the cause of at least 10% of all cases of renal failure. Once recognized and treated by temporary drainage, recovery of some renal function occurs in approximately 80% of patients. However, when severe uremia continues, surgical intervention is not recommended because of increased mortality. In the face of decreased renal function, either appropriate temporary drainage or hemodialysis should be instituted prior to prostatectomy. Catheter drainage produces improvement within 2 weeks in almost all cases.

Another result of change in renal function that must be considered in any discussion on this subject is that which is associated with postobstructive diuresis. This has been attributed to decreased sodium reabsorption by the distal tubule and collecting duct and a water-losing tendency. The pathophysiology of this disorder is discussed below, but it should be noted that it is not peculiar to BPH.

In many of our patients other diseases may also contribute to the overall loss of renal function. We do not discuss them all but do consider the changes due to aging to be separate from BPH, as BPH is a disease of the aging population of men. Senescence is our fate. The biological effects of aging on the kidney can be shown by both anatomical and physiological changes. Both renal mass and function decrease beginning at age 40, reaching a reduction of 20–50% by age 70. The loss of renal function is probably due to changes in renal or intrarenal arteries and thus represents ischemic atrophy and nephron loss. The loss appears to be more cortical than medullary, although the loss of concentrating ability shows that the renal medullary concentration gradient is not maintained. The loss of concentrating ability is not the only reason for nocturia, but neither is prostatic obstruction.

Finally, we describe our method of determining when prostatic obstruction is significant. Urodynamic studies may reveal the hydrodynamics of the disorder, and residual urine is only a sign of prostatic obstruction and the failing bladder. Our quantitative radionuclide studies, however, not only show the status of the patient’s renal function
but indicate which patients have obstructive uropathy, even before serum creatinine or radiologic changes occur.

Renal Pathophysiology of Chronic Partial Bilateral Urinary Obstruction

As Gillenwater\textsuperscript{14} so succinctly said, “the pathophysiologic effects of short-term complete obstructive uropathy or chronic partial obstructive uropathy can be summarized simply. All renal function except dilution are progressively impaired. The longer or more severe the obstruction, the more renal damage will result.” Preexistent renal parenchymal and renal vascular disease, as commonly found in the male affected by obstructive disease from BPH (see below), make some more susceptible to the effects of this obstruction. The effects on renal function of aging alone are similar to the pathophysiological change seen with BPH. Therefore the following animal experiments, which isolate the effects of obstruction to better understand it, are not entirely comparable to bladder neck obstruction in man. In man, obstruction is not a singular problem. In addition to normal physiological changes and the effects of other renal disease, the presence of infection compounds the problem. However, as a basis for our understanding, the experimental animal data are discussed.

Experimental Studies

In early chronic partial ureteral obstruction, intrapelvic pressure increases to 20–25 mm Hg, normally (in antidiuresis) being $6.5 \pm 2.1$ mm Hg. This pressure decreases to normal, or even below normal, as the duration of the obstruction increases. Proximal intratubular pressure is only slightly increased (17 mm Hg compared to a normal of 12 mm Hg) in the presence of chronic partial obstruction.\textsuperscript{40}

The cupped shape of the renal calyx and the epithelium around the papillary ducts protects the renal substance from tubular backflow in early chronic obstructive disease. However, as hydronephrosis progresses, clubbing of the calices occur as the papilla inverts, and tubular backflow results.\textsuperscript{19} We have shown that the normal shape of the papilla is thus a protective mechanism in ascending infection, as the pressure necessary for pyelotubular backflow (by which delivery of bacte-

ria to the kidney occurs) decreases as the papilla flattens from obstruction.\textsuperscript{40} This explains the increased susceptibility of the kidney to infection during ureteral obstruction.\textsuperscript{17}

The kidney continues to produce urine in the face of bilateral partial ureteral obstruction, but transport of urine from the upper collecting structures to the bladder is impaired. Urine is therefore reabsorbed. Hinman described three sites of the absorption in chronic obstruction: 1) very early, by pyelovenous backflow occurring at the fornix of the minor calyces; 2) then tubular backflow with tubulovenous and tubulolymphatic absorption; and 3) less importantly, pyelolymphatic backflow.\textsuperscript{19} Gillenwater\textsuperscript{14} states that 80–90% of the filtrate in chronic hydronephrosis is reabsorbed by the tubules and exits by the renal veins, although with low pressures (very early in hydronephrosis) most of the fluid enters the lymphatics. In our studies in the primate, when pressure is raised in the renal pelvis, pyelotubular backflow first occurs at a mean pressure of 32 mm Hg. Pyelovenous, pyelolymphatic, and tubular interstitial backflow occur at much higher pressures (>100 mm Hg). After obstruction the pressure necessary for pyelotubular backflow decreases markedly.\textsuperscript{1} The rate of resultant hydronephrotic renal atrophy is greater in high than low ureteral obstruction, indicating some protection by the ureteral lymphatics. This may be because the effects of diuresis (which would increase pressure) are not as marked in lower obstruction.\textsuperscript{49} When renal and ureteral lymphatics are removed at the time of obstruction, greater dilation of the collecting structures occurs,\textsuperscript{19} and there is an increased loss of sodium, chloride, and water.\textsuperscript{14}

Early in hydronephrosis there is increase in renal size because of tubular filling and interstitial edema. Continued increased pressure produces renal vascular change and subsequent cellular atrophy and necrosis. Thus the renal atrophy of hydronephrosis finally occurs.\textsuperscript{29} In animal models atrophy begins in the distal nephron within 7 days, and by 14 days it exists in the cortical regions.\textsuperscript{14} Functional vascular derangement and dilation of tubules are the important factors producing renal atrophy as opposed to parenchymal compression against a constricting capsule.\textsuperscript{19} No anatomical changes in the arteries have been seen, indicating that the renal vascular changes observed are functional in nature.\textsuperscript{14}

One factor that explains variability in the results