# Renal Medicine

Written to introduce the student, house officer, family physician and internist to the fundamentals of renal function, this volume presents a short summary of basic renal structure, renal physiology, renal failure and more common renal diseases. Glomerulonephritis is emphasized, as it accounts for approximately two-thirds of the patients on dialysis or in a renal transplant program. Attention is also given to drugs in renal failure, obstructive renal disease, interstitial nephritis and the hereditary diseases of the kidney. Carefully selected illustrations and comprehensive references are included.


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*By*

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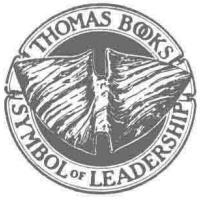


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# RENAL MEDICINE

TO MY WIFE PATRICIA

# PREFACE

THIS BOOK is not written for the nephrologist nor for the physician versed in the study of nephrology. It is written rather for the student, house officer, and physician as an introduction to renal medicine gathered from the fifteen years experience of the author in the study and practice of nephrology. Much emphasis is given to acute and chronic renal failure, to drugs and the kidney, and to the immunological diseases of the kidney. This emphasis is by design since, in the experience of the author, these subjects account for the majority of consultations in nephrology. It is the sincere desire of the author that this text will offer a better understanding of renal medicine if consultation with a nephrologist is necessary. References in some areas of the text may seem more than adequate; however, they have been selected with care to offer as complete a guide as possible to an in-depth research for the physician interested in a particular problem in nephrology.

The writer wishes to thank his secretary, Mrs. John Ooton, for her invaluable aid. The writer also thanks his associates, Doctors Donald E. Wells and T. H. Lee, who have encouraged and supported his efforts with the time necessary in the preparation of the manuscript. Finally, I want the reader to understand the extensive work, patience and sacrifice that my wife, Patricia, has offered in my endeavors in both the practice of medicine and in the preparation of this book.

R.G.M.

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# RENAL MEDICINE

*Chapter 1*

# RENAL STRUCTURE

## GROSS MORPHOLOGY

THE KIDNEYS are retroperitoneal paired organs lying in the posterior aspect of the abdomen. Although their position is variable, the upper and lower poles are usually between the twelfth thoracic vertebra superiorly and the third lumbar vertebra inferiorly. The adult kidney averages 150 grams in weight and measures 11.5 cm in length, 6 cm in width, and 2.5 cm in thickness. The kidney is surrounded by a fibrous capsule. A bisected kidney shows two distinct zones. The outer zone is lighter in color and contains most of the glomeruli and the proximal and distal convoluted portions of the tubules. This zone is called the cortex. The inner zone called the medulla is darker and contains the major portion of the tubules and collecting ducts. The medulla consists of two zones. The outer zone contains part of the proximal convoluted tubules, the collecting tubules, and the thick portion of the ascending limb of the tubules. The inner zone contains primarily collecting ducts and also the thin portion of the renal tubules and the vasa recta. The corticomedullary junction is the region where the cortex blends with the medulla. The cortex projects into the medulla, partially separating it into cone-shaped sections called the pyramids of the medulla. The distal part of the pyramid, lighter in color, is called the papilla. The cortical projections into the medulla are called the columns of Bertin. These areas are readily seen diagrammatically. The vascular supply, lymphatics, nerve supply, and renal pelvis are on the medial aspect of the kidney, the hilus.

Each kidney is usually supplied by a single artery arising from the aorta. Approximately 25 percent of the kidneys, however, have multiple renal arteries which usually originate from the

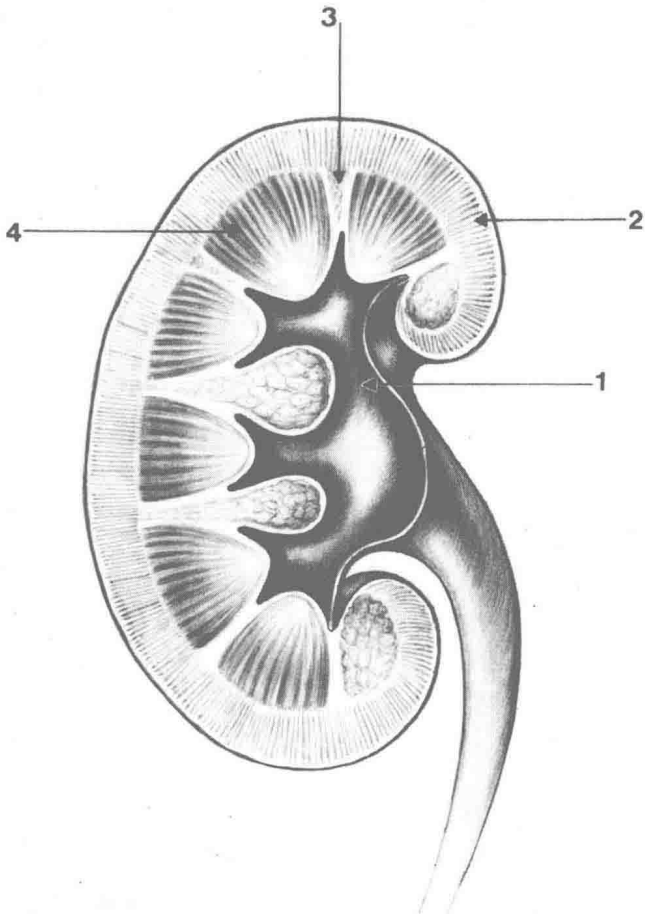


Figure 1. Cross section of kidney. The renal pelvis (1). The cortex (2). The columns of Bertin (3). Pyramid of medulla (4).

aorta, but may also come from branches of the aorta to other retroperitoneal and intra-abdominal organs. The renal artery divides into anterior and posterior branches, usually after it enters the hilus. These two branches divide into segmental branches,

each supplying a specific segment of the kidney.[1] Anteriorly, there are four segments: apical, upper, middle, and lower. Posteriorly, there are the apical, posterior, and lower segments. The segmental arteries are essentially end arteries with minimal or no arterial connection between the segments of the kidney. At the corticomedullary junction, the segmental arteries branch to become the arcuate arteries. The arcuate arteries give rise to the interlobular arteries and terminate as they curve toward the adjacent segment of the kidney. The interlobular arteries supply the afferent arteriole to each glomerulus. The renal vein exits from the kidney at the hilus and joins the inferior vena cava. A single renal vein is usually present. Accessory veins are far less common than accessory arteries.

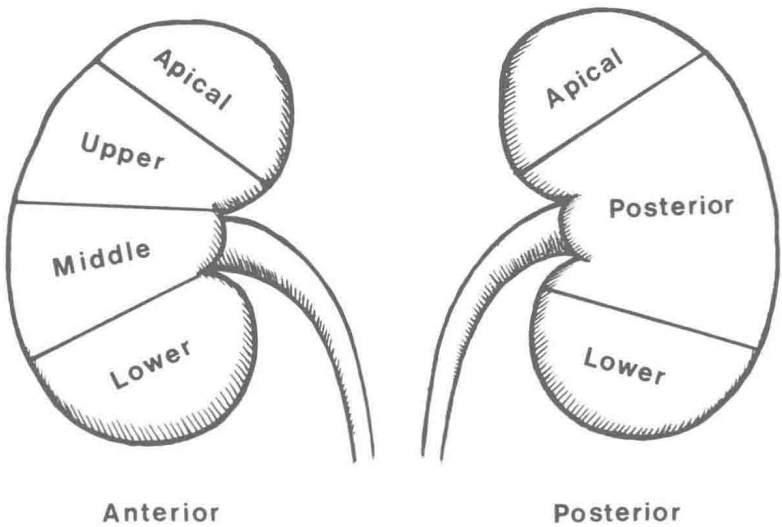


Figure 2. Vascular segments of the kidney.

The renal pelvis tapers from the hilus of the kidney to form the upper end of the ureter. Within the hilus of the kidney there are two or three large pouches, or major calyces, extending into the kidney. From each major calyx, several minor calyces extend farther into the kidney and envelope the papillae, thus gathering the urine from the collecting ducts. The structure of the renal pelvis is clearly seen in an excretory urogram. The renal

pelvis may be duplicated, draining into a common ureter. More rarely, both the pelvis and ureter are duplicated.

Figure 3. Excretory urogram showing normal calyces and pelvis.

## THE NEPHRON

The nephron consists of the glomerulus and the renal tubule. Each kidney contains about 1.2 million nephrons. The glomeruli, though microscopically similar, may differ in function depending upon their location in the renal cortex. The difference is mainly a result of the structure of the renal tubule. The renal tubule has several components. The proximal tubule consists of a convoluted portion which drains Bowman's space surrounding the

glomerulus and a straight portion which descends toward the medulla. The straight portion is the first part of the loop of Henle and abruptly changes to form the thin part of the loop of Henle. As the name implies, there is indeed a loop. The loop turns in the medulla and, while remaining thin, ascends toward the cortex. In its ascent, it also abruptly becomes thick, appropriately called the thick portion of the ascending limb of the

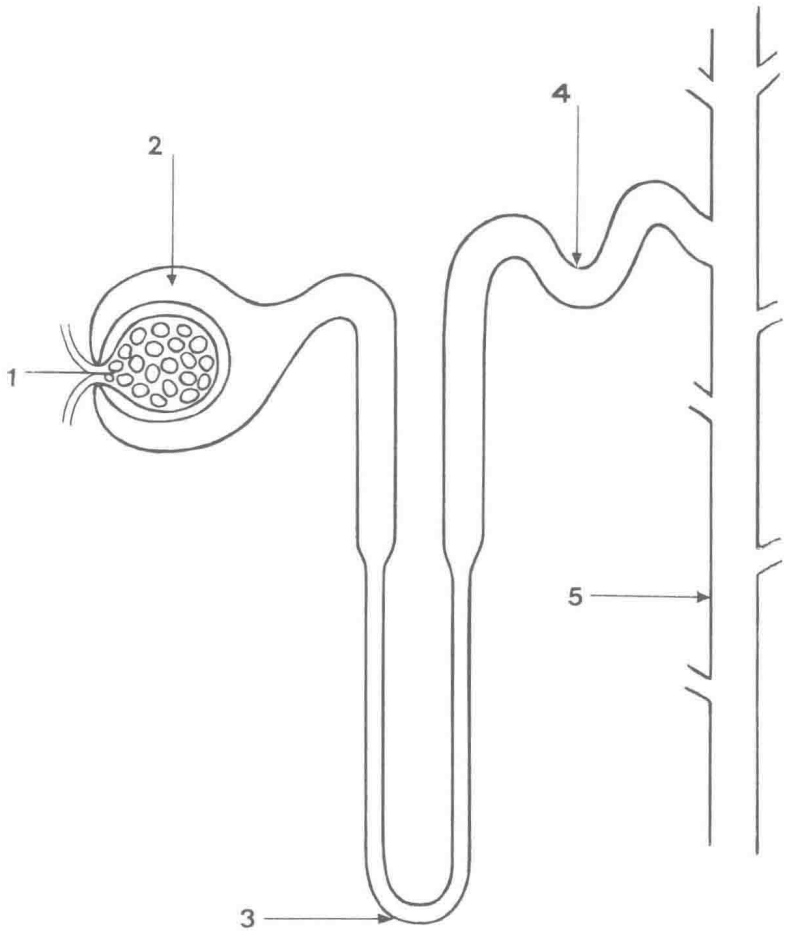


Figure 4. The nephron. The glomerulus (1). Bowman's space (2). The loop of Henle (3). The distal convoluted tubule (4). The collecting duct (5).

loop of Henle. In the cortex, the ascending limb becomes the distal convoluted tubule and drains into a collecting duct. It must be noted that many nephrons drain into each collecting duct.

As mentioned above, nephron function is largely a matter of placement in the cortex. The cortical nephrons have very short thin segments of the loop of Henle. These segments may penetrate only a small distance into the medulla. Conversely, juxtamedullary nephrons have very long thin segments running deep into the medulla. There are many nephrons, of course, between the very superficial cortical and the deep juxtamedullary nephrons. The great majority of nephrons are located in the more superficial area of the cortex. The nephron functional differences are the result of their relative location in the cortex and include changes in water and electrolyte excretion, renal blood flow, etc. These differences are discussed in Chapter 2.

The glomerulus consists of a capillary network fed by the afferent arteriole and drained by the efferent arteriole. Each glomerulus lies in a spherical space, the urinary space, which is lined by the glomerular capsule, known as Bowman's capsule. Bowman's capsule contains a basement membrane and the parietal epithelial cells. Normally, these epithelial cells are quite flat in appearance. The glomerular capillary network has a supporting structure, the mesangium, consisting of mesangial cells. Each capillary loop has a basement membrane which is lined on the inside by endothelial cells and on the outside by the visceral epithelial cells whose foot processes touch upon the basement membrane. This anatomical arrangement is best depicted diagrammatically. Under very high magnification with the electron microscope, there are filtration slit pores between the visceral epithelial cell foot processes where they abut upon the capillary basement membrane. Similar pores also exist in the endothelial cell cytoplasm lining the inside of the capillary loop.[2] The basement membrane in the normal kidney has a rather uniform thickness. The capillary loop basement membrane, the visceral epithelial cell foot processes, and the endothelial cell cytoplasm with their respective filtration pores play the most prominent role in the initial formation of urine, which is an ultrafiltrate of plasma. These structures also control the filtration