Fundamentals of Renal Pathology

Agnes B. Fogo
Author
Arthur H. Cohen
Robert B. Colvin
J. Charles Jennette
Charles E. Alpers
Co-Authors

Second Edition

Springer

Fundamentals of Renal Pathology

Agnes B. Fogo
Author

Arthur H. Cohen • Robert B. Colvin
J. Charles Jennette • Charles E. Alpers
Co-Authors

Fundamentals of Renal Pathology

Second Edition

Springer

Agnes B. Fogo
Department of Pathology, Microbiology and Immunology
Vanderbilt University Medical Center
Nashville, Tennessee
USA

Arthur H. Cohen
Department of Pathology and Laboratory Medicine
Cedars-Sinai Medical Center
Los Angeles, California
USA

Robert B. Colvin
Department of Pathology
Harvard Medical School
Massachusetts General Hospital
Boston, Massachusetts
USA

J. Charles Jennette
Department of Pathology and Laboratory Medicine
University of North Carolina
Chapel Hill, North Carolina
USA

Charles E. Alpers
Department of Pathology
University of Washington
Seattle, Washington
USA

ISBN 978-3-642-39079-1 ISBN 978-3-642-39080-7 (eBook)
DOI 10.1007/978-3-642-39080-7
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013950483

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Part I

Renal Anatomy and Basic Concepts and Methods in Renal Pathology

Renal Anatomy and Basic Concepts and Methods in Renal Pathology

1

Normal Anatomy

Each kidney weighs approximately 150 g in adults, with ranges of 125–175 g for men and 115–155 g for women; both together represent 0.4 % of the total body weight. Each kidney is supplied by a single renal artery originating from the abdominal aorta; the *main renal artery* branches to form anterior and posterior divisions at the hilus and divides further, its branches penetrating the renal substance proper as *interlobar arteries*, which course between lobes. Interlobar arteries extend to the corticomedullary junction and give rise to *arcuate arteries*, which arch between cortex and medulla and course roughly perpendicular to interlobar arteries. *Interlobular arteries*, branches of arcuate arteries, run perpendicular to the arcuate arteries and extend through the cortex toward the capsule (Fig. 1.1). *Afferent arterioles* branch from the interlobular arteries and give rise to glomerular capillaries (Fig. 1.2). A *glomerulus* represents a spherical bag of capillary loops arranged in several lobules (Fig. 1.3); the capillaries merge to exit the glomerulus as *efferent arterioles*, which, in most nephrons, branch to form another vascular bed, peritubular or *interstitial capillaries*, which surround tubules. Efferent arterioles from juxtamedullary glomeruli extend into the medulla as vasa recta, which supply the outer and inner medulla. The vasa recta and peritubular capillaries collect, forming into *interlobular veins*; the veins follow the arteries in distribution, size, and course and leave the kidneys as *renal veins*, which empty into the inferior vena cava.

The kidneys have three major components: the cortex, the medulla, and the collecting system. On the cut surface, the cortex is the pale outer region, approximately 1.5 cm in thickness, which has a granular appearance because of the presence of glomeruli and convoluted tubules. The medulla, a series of pyramidal structures with apical papillae, numbers normally 8–18 and has a striped or striated appearance because of the parallel arrangement of the tubular structures. The bases of the pyramids are at the corticomedullary junction and the apices extend into the collecting system. Cortical parenchyma extends into spaces between adjacent pyramids; this portion of the cortex is known as the columns of Bertin. A medullary pyramid with surrounding cortical parenchyma, which includes both columns of Bertin and

A.B. Fogo et al., *Fundamentals of Renal Pathology*,
DOI 10.1007/978-3-642-39080-7_1, © Springer-Verlag Berlin Heidelberg 2014

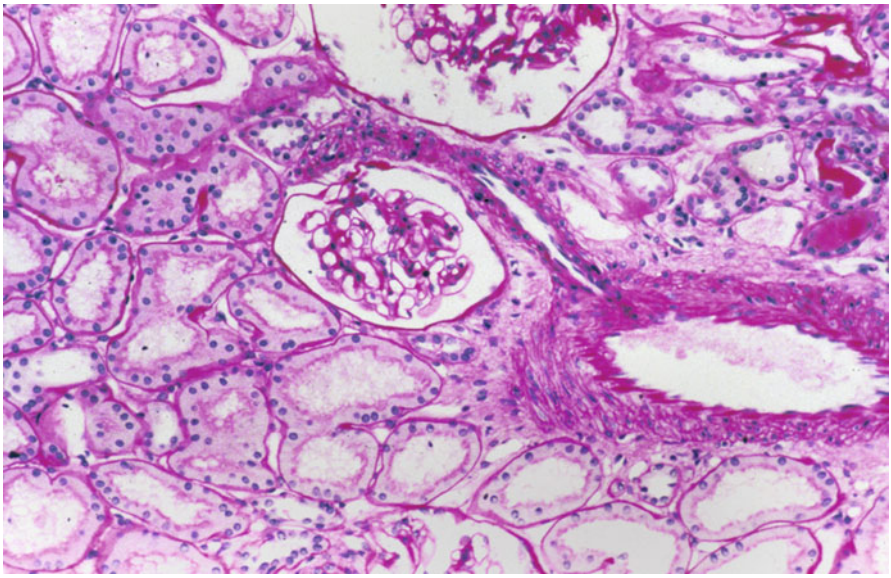

Fig. 1.1 Low magnification of cortex with portions of two glomeruli, tubules, and interstitium and interlobular artery with arteriolar branch [periodic acid-Schiff (PAS) stain]

the subcapsular cortex, constitutes a renal lobe. The collecting system consists of the pelvis, which represents the expanded upper portion of the ureter, and is more or less funnel shaped. Each pelvis has two or three major branches known as the major calyces. Each calyx divides further into three or four smaller branches known as minor calyces, each usually receiving one medullary papilla.

Each kidney contains approximately one million nephrons, each composed of a glomerulus and attached tubules. Glomeruli are spherical collections of interconnected capillaries within a space (Bowman's space) lined by flattened parietal epithelial cells (Fig. 1.3). Bowman's space is continuous with the tubules, with the orifice of the proximal tubule generally at the pole opposite the glomerular hilus, where the afferent and efferent arterioles enter and leave, respectively. A layer of visceral epithelial cells, also called podocytes, covers the outer aspects of the glomerular capillaries. Each podocyte has a large body containing the nucleus and cytoplasmic extensions, which divide, forming small fingerlike processes that interdigitate with similar structures from adjacent cells and cover the capillaries. These interdigitating processes, known as pedicles, are also called foot processes because of their appearance on transmission electron microscopy. The space between adjacent foot processes is known as the filtration slit; adjacent foot processes are joined together by a thin membrane known as the slit-pore diaphragm. The slit diagram is composed of a complex of the transmembrane proteins nephrin, NEPH1 through NEPH3, podocin, Fat1, VE-cadherin, and P-cadherin. Mutations in NEPH1 and podocin cause proteinuria. Epithelial cells cover the glomerular capillary basement membrane, a three-layer structure with a central thick layer slightly electron-dense

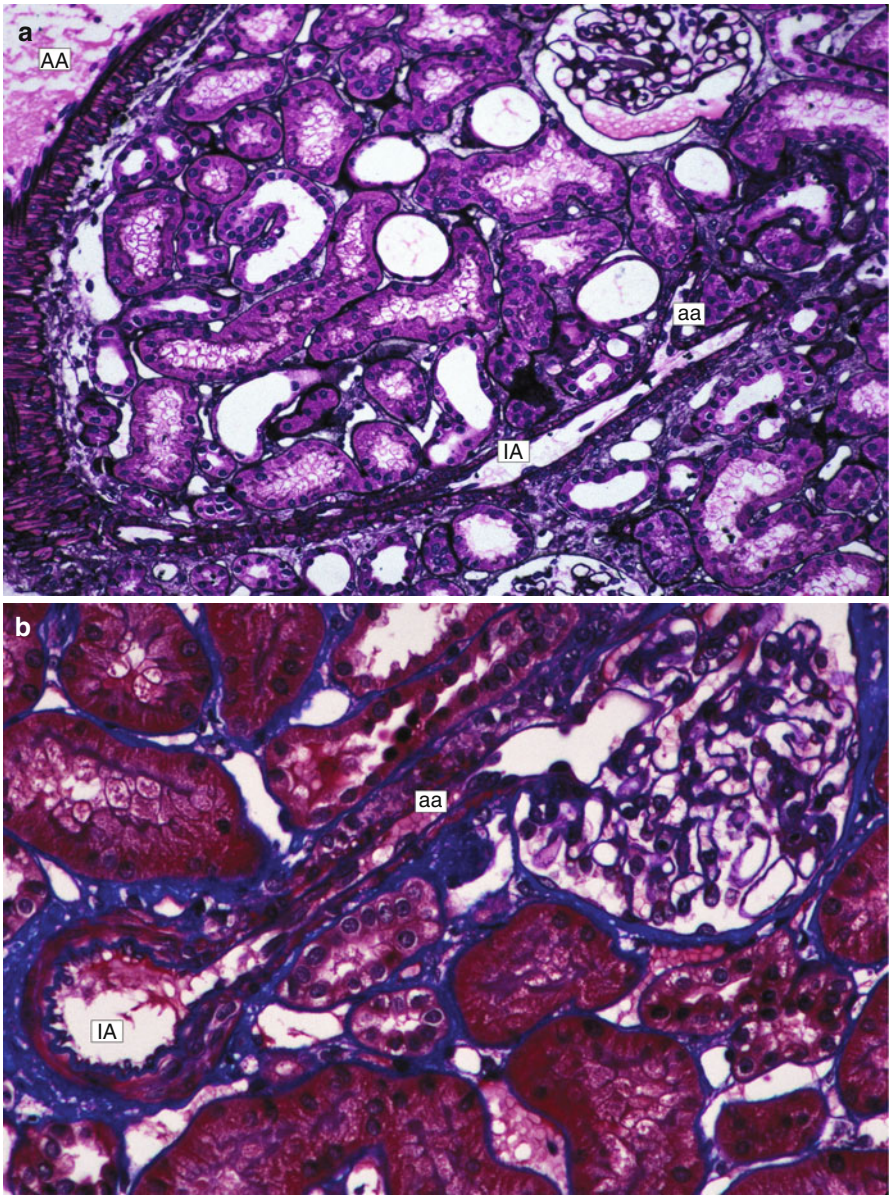

Fig. 1.2 (**a**) Low magnification of cortex. An arcuate artery (*AA*), interlobular artery (*IA*), and afferent arteriole (*aa*) are in continuity (Jones silver stain). (**b**) Interlobular artery (*IA*) with afferent arteriole (*aa*) extending into glomerulus (Masson trichrome stain)

(lamina densa) and thinner electron-lucent layers beneath epithelial and endothelial cells (lamina rara externa and lamina rara interna, respectively) (Fig. 1.4). The glomerular basement membrane is composed predominately of type IV collagen with