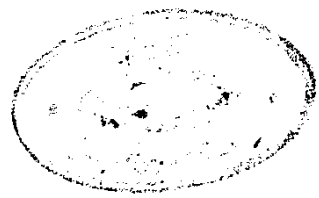
RADIONUCLIDE RENAL SCANNING

ESSAY

Submitted for partial fulfilment of

Master Degree in Urology



BY

MOHAMED AWNY ALY AHMED LABIB

SUPERVISED BY

PROF. DR. MOHAMED AMIN TAHA

PROFESSOR OF UROLOGY DEPARTMENT

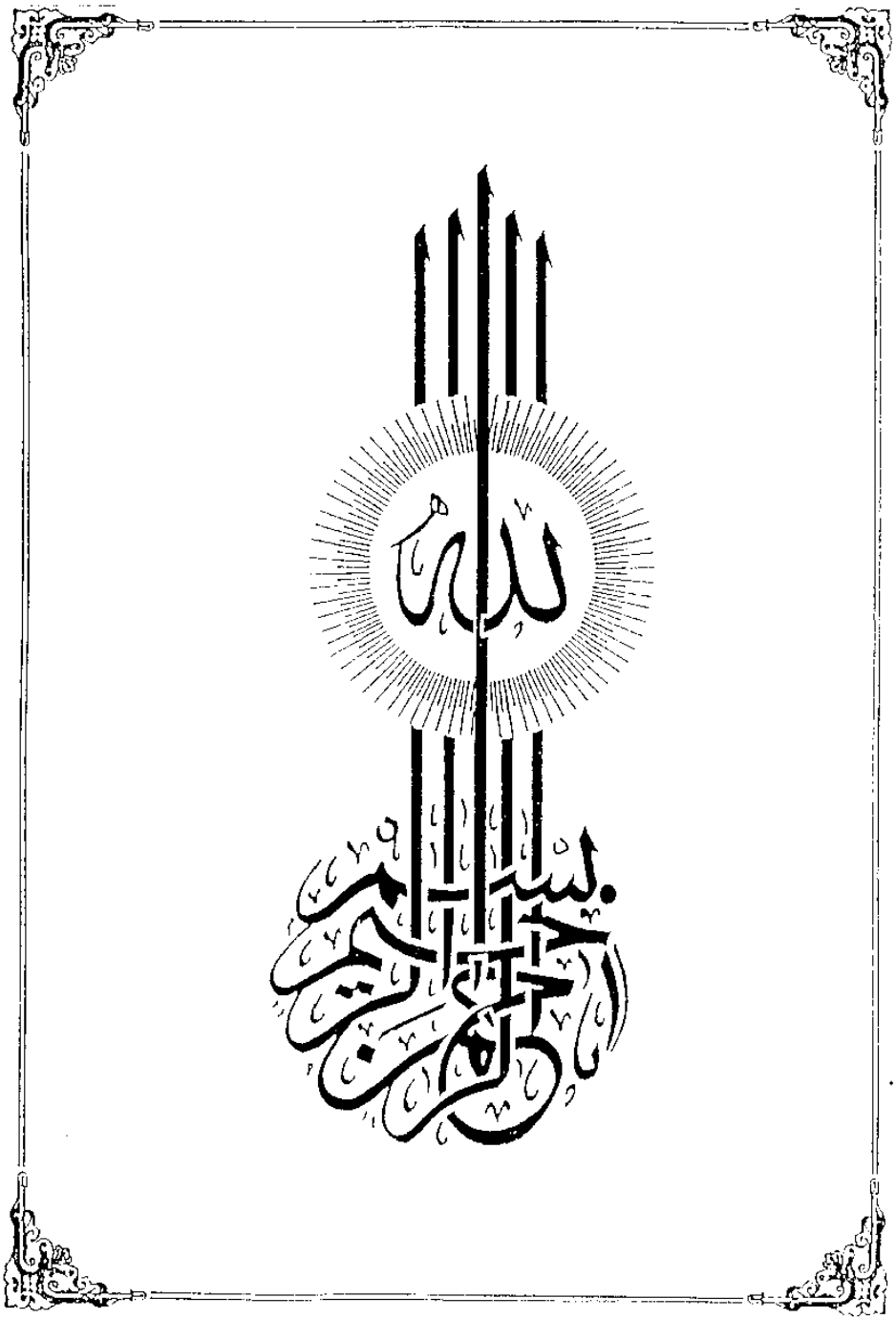
FACULTY OF MEDICINE

AIN SHAMS UNIVERSITY

1986

CONTENTS

==========



ACKNOWLEDGEMENT

I wish to express my limitless gratitude to Prof. Dr. Mohamed Amin Taha, Professor of Urology Department, Faculty of Medicine, Ain Shams University, who put me on the first step. His kind supervision and parent attitude could not be denied. Also, his continuous guidance and kind encouragement and support throughout the work makes it very clear and precise.

I wish, also, to extend my thanks to all members of Urology Department of Ain Shams University for their great help.

My supreme gratitude goes to Prof. Dr. Gammal El-Baz, Head of Urology Department, El-Sahel Teaching Hospital for his continuous encouragement and great help during preparation of this essay.

INTRODUCTION

Urinary tract functions are necessary to maintain life, as congenital abscence or major deficits in its parts are incompatible with life. Its main function is formation of urine and its conduction to the exterior.

In the work-up of any patient, history is of paramount importance, this is particularly true in urology. But also investigations are as well important, as it aids much the physician and surgeon to reach the full diagnosis and know exactly the renal functions. There was much increase in our knowledge during the last 30 years about urinary tract physiology; and consequently many functional tests became known and rationalised. Some of these tests are too delicate, or too complicated to be applied in clinical practice. However, the recent use of radioisotopes in this field has circumvented much of the drawbacks of conventional tests.

Radionuclide studies of the kidney and renal outflow tract enables various functions to be measured objectively. Serial measurements may be made to detect any change in function during the observation of patients in whom surgery is not yet thought to be indicated. The techniques of radionuclide investigation

generally involve no more than an intravenous injection to the patient and the absorbed radiation dose is typically much less than that given during X-ray studies of the kidney.

The purpose of this work is to give an idea about the role of radioisotopes in helping the urologists in diagnosis of urinary tract diseases.

HISTORICAL REVIEW

The history of development of radiosotope renography, a test depending on radioisotopes, began since the second world war. It was the abundant production of radioisotopes as a by product of the Manhattan Atomic Bomb project, which then became available to the medical proffession for peaceful uses.

The external detection of gamma rays emitted by radioisotopes within the body was made feasible by the development of the scintillation counter in 1947 by Kollman of Germany and other similar devices in other countries of the world.

Oeser and Billion (1952 Germany) reported on the use of Iopex ^{131}I in humans. They collected urine at timed intervals and then plotted the levels of radioactivity in graphic form. They did not employ external radiation detection and recording equipment and did not anticipate the clinical application of such methods.

Kimball of Berlin in 1956 published a discussion related to the recording of levels of radioactivity over the heart and kidney following the injection of ^{131}I perbrodil M and urographin.

Winter (1956), the pioneer of radioisotopes, published his first paper on the subject in the journal of urolog in August 1956.

Taplin and Winter (1958) produced an activity-time curve on a chart recorder of the renal scintillation following intravenous injection of ^{131}I-labelled diadrast.

Two years later, McFee and Wagner (1960), using ^{203}Hg - labelled neohydrin and a rectilinear scanner, obtained the first detailed isotope images of the kidney.

When diadrast gave way to the superior Hippuran (Tubis, 1960) and ^{203}Hg. to the less radiotoxic ^{197}Hg (Sodee, 1964), the new speciality of nuclear medicine was welcomed as a significant advance in investigative urology.

CHAPTER I

HINT ON THE PHYSIOLOGY OF THE KIDNEY

Renal Circulation:

The kidneys regulate the volume and composition of the body's extracellular fluid through their excretory function. They also play an important role in circulatory dynamics because under normal conditions they receive 1/4 of the cardiac output.

The kidneys are supplied by the renal arteries (Fig. 1) which are branches of the aorta. Each renal artery enters the renal hilum and divides into five labor branches, which in turn give rise to the interlobar arteries in the renal columns of the medulla. At the medulla-cortex junction the interlobar arteries branch out into the arcuate arteries, which at intervals give rise to interlobular arteries penterating upwards into the renal cortex.

Nephron Circulation:

After entering the cortex (Fig. 2), the interlobular arteries branch out into the afferent arterioles, which terminate as tufts of capillaries, the glomeruli, numbering over one million per kidney. These capillary beds do not reform into venules but into efferent arterioles,

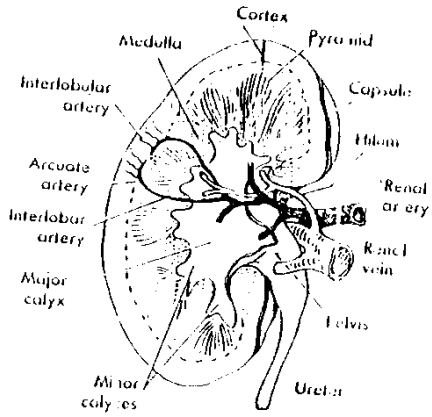


Fig. 1 Diagram of coronal section of right kidney, vascular distribution of renal artery (black) is magnified for clarity, (From Richard, J.B.: Nuclear Medicine technology and techniques, 1981, the C.V. Mosby co.).

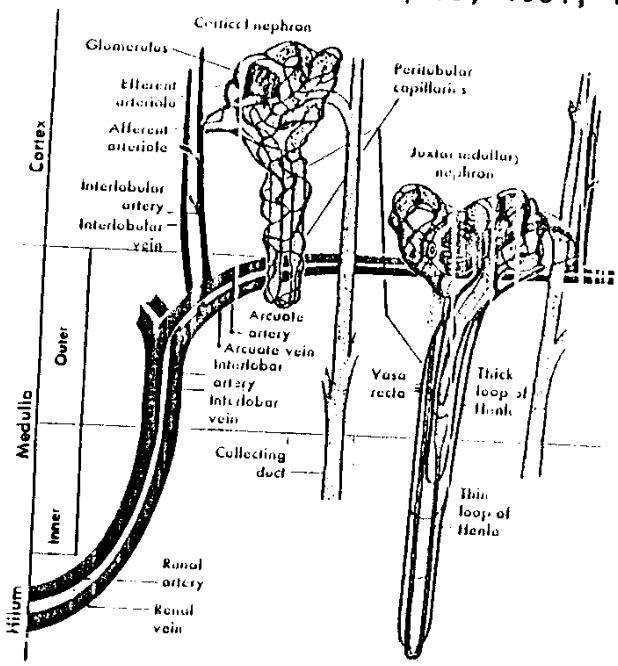


Fig. 2: Schematic representation of nephron circulation, and respective location in kidney structure. (From Hamilton, W.J. Textbook of human anatomy, 1976, the C.V. Mosby co.).

which leave the glomeruli and ramify into a network of capillaries (peri-tubular capillaries and vasa recta) enmeshing the entire tubular system of the nephron. It is from this second capillary bed that the venules unite to initiate the venous return with the interlobular veins and complete it through the arcuate veins, interlobar veins, and renal veins, which leave the renal hilum and empty into the inferior vena cava.

The Nephron:

The functional unit of the kidney, the nephron (Fig. 3), consists of a glomerulus and a renal tubule, and lies for the most part in the renal cortex. In the cortex, there are glomeruli of two types of nephrons: cortical and juxta-medullary nephrons.

Cortical nephrons have muscular afferent arterioles sensitive to sympathetic activity (constrictor) and dopamine (dilator) which, with the macula densa segment of the distal tubule, form renin-containing juxta-glomerular apparatus. Their glomeruli are mainly in the aouter 2/3 of the cortex and they have short

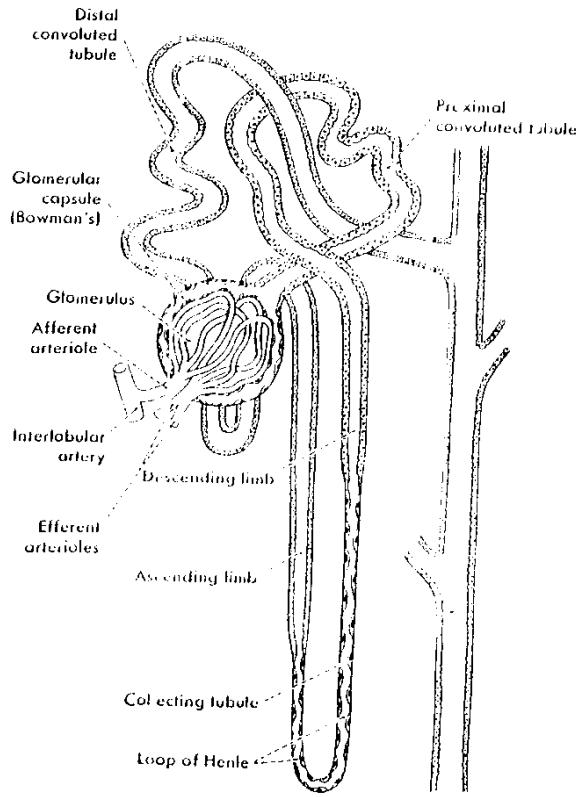


Fig. 3: Simplified diagram of nephron, (From Hamilton, W.J. Text book of human anatomy, 1976, the C.V. Mosby Co.).

Henle's loops. They have the property of autoregulation, that of maintaining a nearly constant blood flow in the face of changes in blood pressure over a wide physiological range.

Juxta-meduallary neprhons differ in having their glomeruli near the medulla, in having no juxta-glomerular apparatus, and in having long Henle's loops. Their muscular efferent arterioles are under the control of the sympathetic system and vasopressin (constrictor), and prostaglandins (dilator) and they do not show autoregulation.

The glomerulus is a tuft of capillaries enclosed by a capsule (Bowman's capsule), which is actually an expanded, invaginated portion of a renal tubule. As it arises from the Bowman's capsule, the tubule follows a tortuous course and hence is termed the proximal convoluted tubule; then it proceeds straight, dips downward into the medulla, makes a hairpin turn (Henle's loop) upward, and returns to the vicinity of the glomerulus where again it assumes a winding course named the distal convoluted tubule and finally ends in collecting tubule. The collecting tubule passes downward through the medulla as a component of a renal pyramid, joins larger tubules, which converge to form one tube that opens at a renal papilla into one of the minor

calyces; these converge into the major calyces, which compose the renal pelvis and funnel into the ureter (Richard, 1981).

Clearance:

Renal clearance is represented by the volume of blood or plasma that is completely cleared of any substance per unit time. The values needed to calculate plasma clearance, C, are:

- The concentration of a substance in the urine, U, (mg/ml).
- The concentration of the same substance in plasma, P, (mg./ml)
- the rate of urine flow, V, (ml/min).

Thus,

$$C = UV/P$$

Where, C is expressed in ml/min.

Excretion:

Three processes are involved in urine formation: glomerular filtration, tubular reabsorption, and tubular excretion.