# HEMODIALYSIS

ESSAY

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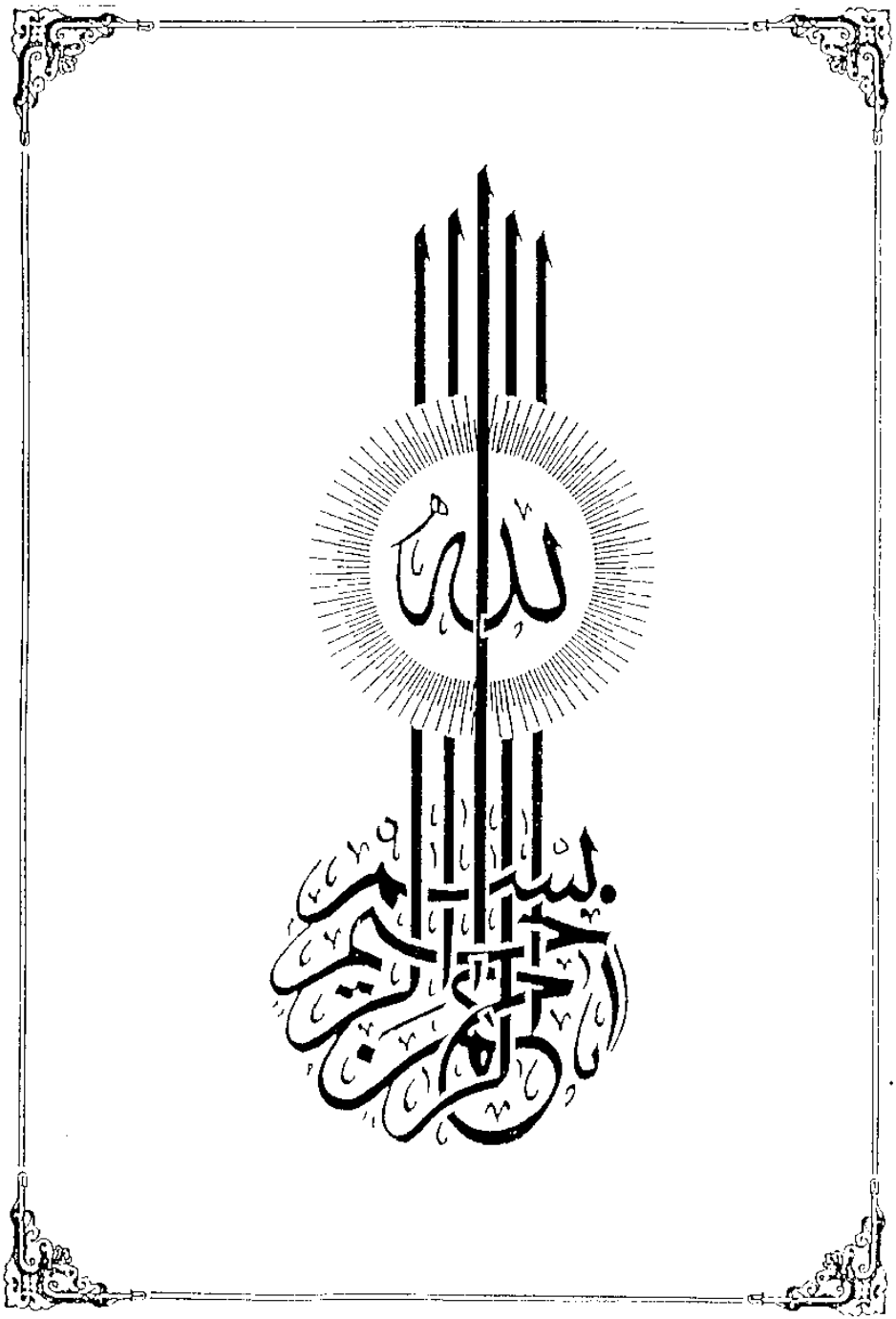
بسم الله الرحمن الرحيم

وَمَا أُوتِيتُم مِّنَ الْعِلْمِ إِلَّا قَلِيلًا

صدق الله العظيم



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# INTRODUCTION

# INTRODUCTION AND HISTORY OF DIALYSIS

Hemodialysis is a vital modality of treatment not only for the unfortunate cases of chronic end stage renal failure, once doomed for their fate few decades ago, but also for the acutely failing kidneys. In the former group hemodialysis offers a reasonable sort of life, suitable for contineuing some simple activities for a period of few monthes, few years until some of the fortunate patients undergo a successful allograft transplantation. For those patients with acute renal failure whether spontaneous or post traumatic, it is a life saving procedure which tides the patients over the critical period of renal shut down until the healing nephrons regain their faculties. For these reasons every practising urologist must have a sound idea about the whole subjects of hemodialysis.

Dialysis utilizing membranes to allow the passage of small molecules through them but not large molecules was first described by the scottish chemist, ***Thomas Graham in 1854.***

The first description of the dialysis of human blood is by the English researcher, ***B. W. Rich ardson in 1859.*** Using colodion membranes, he separated the substances of blood and other body flurds into two groups : crystalloid

substances [which readily pass through the membranes] and colloid substances [which do not pass through the membranes]

Abel, Rowntree, and Turner, working at the johns Hopkins University in Baltimore, are accredited with performing the first true hemodialysis. They designed an apparatus which looks remarkably simillar to today's hollow fiber capillary dialyzers.

First hemodialysis in the United States was performed by Hess and McGuigan at North western University Medical School in chicago, Illinois [***Van Stone J.C., et al., 1983***].

The first hemodialysis donein humans was done in ***Germany in 1915 by George Haas*** at the University. Clinic of Giessen.

He used a device very similar to that of Abel, vtilizing colloidal membranes. In order to obtain sufficient surface area, he connected as many as such devices in paralled. He used a continuous flow system with the use of a blood pump to propel the blood through his many devices.

Another German researcher, ***Heinrich Necheles,*** warking at peking University in china designed a dialyzer using sheep peritoneum for the membranes [***Drukker W. 1983***].

In *1937 in Germany, Thalhimer* discovered that material made for packaging sausages could be used as a dialyzing membrane.

This material, cellophane, made from cellulose rapidly became used in most dialysis for the ensuing 40 years.

The clinical adaptation of the use of dialysis for the treatment of renal insufficiency has to be credited to willmen kolff.

Kolff attacked the proplem of developing a functional artificial kidney in a scientific manner. However, all patients eventually died because the treatments required cut down arteriotomy for blood access and eventually blood access was impossible. After his intial experiences, kolff limited his dialysis effort to patients with reversible acute renal failure.

In *1948, Skeggs and Leonard at Western Reserve* University in Cleveland, Ohio described the first paralled dialyzer

In *1960 Drs. Wayne Quinton and Belding Scribner* described the first useful device for maintaining permanent access to the circulation. Their derice was made of Teflon tubing A piece of this tubing was placed in an artery and an

adjacent vein so as to supply blood access and blood return during dialysis [*Van Stone J.C., et al., 1983*].

In 1962 *Drs. Cimino and Brescia* in New YorK described a method which provided adequat blood flow without the implantation of foreign material .They created an arterio venous fistula between the radial artery and adjacent vein. [*Drukker.W., 1983*].

The first hollow fiber dialyzer was descriped in *1966 by Richard Stewart*. The first clinical unit contained 11.000 fibers which provided $1m^2$ of surface area, and it has proved to be a very efficient dialyzer design and rapidly become a very popular clinical dialyzer .

In 1969 May described implantation in the arm of Saphenous veins removed fromthe leg which wer connected from an artery to a vein to provide access for hemodialysis [*Van Stone J.C., et al., 1983*].

# THE NEPHRON AND URINE FORMATION

***Physiologic anatomy*** :

The nephron is the basic functional unit of the kidney. Each human kidney has about one million individual nephrons. The nephron consists of a specialized capillary vascular bed from which fluid is filtered [The glomervlus] connected to a continuum of specialized epithelial segments in which the filtered fluid is converted into urine [The tubules], which are subdivided into three functional divisons: The proximal tubule, the loop of Henle, and the distal nephron [distal convoluted tubules and collecting ducts]. There are 2 types of nephrons :

1. Juxtamedullary nephrons which have larger glomeruli and their loops of Henle descend deep into the renal papilae .
2. Cortical nephrons which have smaller glomeruli and shorter loops of Henle with a more shallow medullary penentration [***Andreoli T.E., et al., 1986***].

The basic function of the nephron is to clear the blood plasma of unwanted substances [particularly the end products of metabolism such as urea, creatinin, and uric acid] and excess plasma ions [as $Na^+$, $K^+$, $cl^-$, $H^+$] as it passes through the kidney. The principal mechanism by which the nephron clear the plasma are :

1. It filters about 1/5 of the plasma through the glomerular mambrane into the tubules of the nepheon.
2. Then, as this filtered fluid flows through the tubules, the unwanted substances fail to be reasorbed whilt the wanted substances, especially the water and many electrolytes, are reabsorbed back into the plasma of the peritubular capillaries .

3. Secretion of some unwanted substances, from the plasma directly through the epithlial cells lining the tubules into the tubular fluid. ***[Guyton A. C., 1986]***.

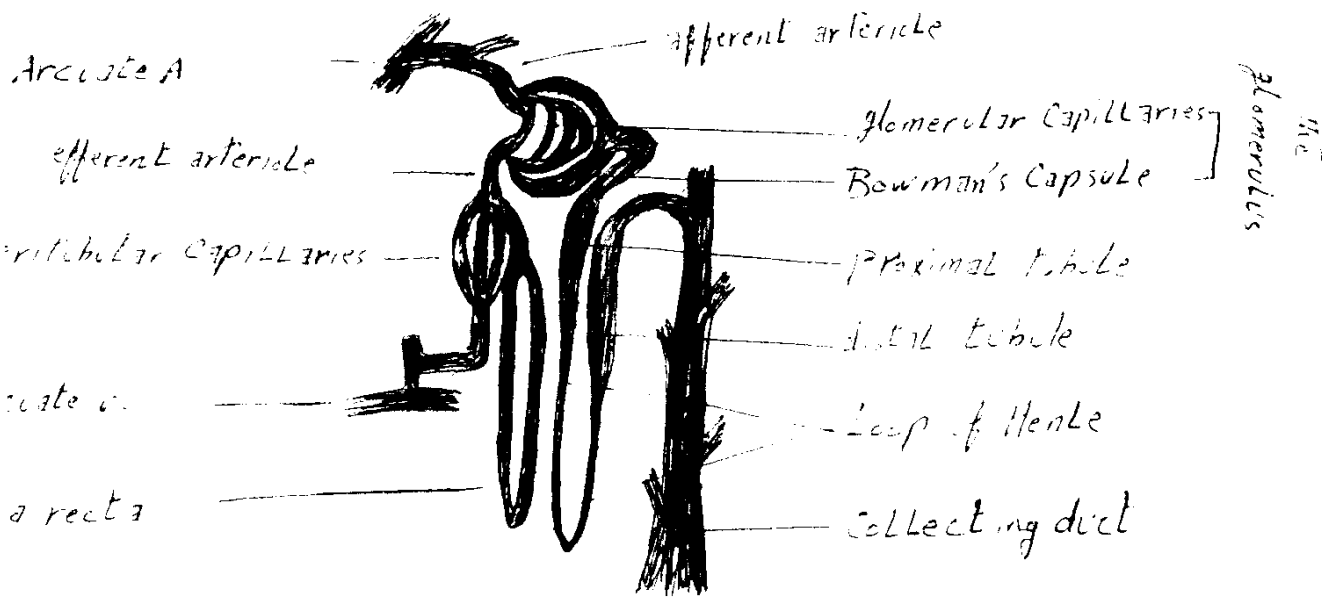
The juxtaglomerular apparatus [JGA] is a distinective region of the nephron composed of both : tubular element [distal convoluted tubule] and vascular element [the afferent and efferent arterials]. It is the site of renin synthesis and secretion with in the kidney ***[Andreoli T. E., et al., 1986]***.

***Special Aspects of blood flow through the nephron :***

- There are two capillary beds supplying the nepheron :
  1. The glomerulus and 2. the peritubular capillaries.
- The glomerular capillary bed receives its blood from the afferent arteriole [a branch from interlobular artery] and ends in the efferent arteriole. Because of the high pressure in the glomerular capillary bed, fluid

filtering continually out of the glomerulus into Bowman's capsule.

- The Peritubular capillaries recive its blood from the efferent arteriole and vasa recta ( a net work of capillaries that descend around the lower portions of the loops of Henle) and end in the inter lobular vein. Because of the lower presure in the peritubular capillaries, fluid absorbed continualy from the interstitial space into the cappilaries. ***[Guyton A. C., 1986].***




***THE FUNCTIONAL NEPHROH***

***[ Guyton A. C., Text Book of Medical Physiology]***

## *1. THE GLOMERULUS*

The glomerulus is formed of glomerular capillaries and Bowman's capsule.

The function of the glomerulus is to deliver a pure ultrafiltrate of the palsma to the proximal tubule. The glomerulus is formed of suspension of capillary network between two resistance vessels, the afferent and efferent arterioles, and this structure mantaine high intracapillary hydrosatic pressure. This high hydrostatic ptessure plus the colloid osmotic pressure of the urinary space favours fluid movement from capillary cavity to urinary space.

The fluid that filter through the glomerulus into Bowman's capsule is called glomerular filtrate, and the membrane of the glomerular capillaries is called the glomerular membrane which has three major layers [ the filteration barrier] : 1. The endothelial layer of the capillary itself, 2. A basement membrane, and 3. A layer of epithelial cells. Thus, glomerular filtrate must pass through 3 different layers before entering Bowman's capsule. Yet, despite the number of layers, the permeability, of the glomerular membrane is from 100 to 1000 times as great as that of the usual capillary. *[Andreoli, T. E. et al., 1986]*.

During ultrafiltration water and small solutes in plasma move freely into urinary space. By contrast, all cells and most macromulecules [ proteins ] are totally excluded from passage into the urinary space due to the structure of the basement membrane which prevent the passage of any solute has molecular diameter more than 7 millimicrons. [Plasma proteins are slightly larger than 7 millimicrons] *[Guyton A. C., 1986]*.

## *2. THE PROXIMAL TUBULE*

The primary function of the proximal tubule is bulk isosmotic reasorption of ultrafiltrate. Under normal euvolemic conditions, about two thirds of ultrafiltrate volume is absorbed. A number of solutes undergo nearly complete reabsorption in the prximal tubule. Glucose, amino acids, calcium, and phosphate are completely resorbed by a mechanism couple to active sodium absorbtion. In the more distal protion of the tubule, secretion of organic acids including uric acid and drugs as pencillins occurs. The end result of absorption in the proximal tubule is delivery of isotonic fluid to the loop of Henle *[Andreoli T. E., et al., 1986]*.