Impact of Hemofiltration on Morbidity and Mortality in Critically Ill Patients

An Essay

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بسم الله الرحمن الرحيم

قالوا سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم

صدق الله العظيم

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List of Abbreviations

ACS	**:**	Acute coronary syndrome
AGN	**:**	Acute glomerulonephritis
AHF	**:**	Acute heart failure
AIN	**:**	Acute interstitial nephritis
AKI	**:**	Acute kidney injury
AKI	**:**	Acute Kidney Injury
AKIN	**:**	Acute Kidney Injury Network
ANP	**:**	Atrial natriuretic peptide
ARDS	**:**	Acute respiratory distress syndrome
ATN	**:**	Acute tubular necrosis
AV	**:**	artery and vein
BBB	**:**	Blood brain barrier
BUN	**:**	Blood urea nitrogen
CAVH	**:**	Continuous arteriovenous hemofiltration
CH	**:**	Charcoal hemoperfusion
CHF	**:**	Congestive heart failure
CIN	**:**	Contrast-induced nephropathy
CKD	**:**	Chronic kidney disease
CRRT	**:**	Continuous renal replacement therapy
CRS	**:**	Cardiorenal syndromes
CVVH	**:**	Continuous venovenous hemofiltration
CVVHD	**:**	Continuous venovenous hemodialysis
CVVHDF	**:**	Continuous venovenous hemodiafiltration
Da	**:**	Dalton
ECG	**:**	Electro-cardiograph
FENa	**:**	Fractional excretion of sodium
FEUrea	**:**	Fractional excretion of urea
GFR	**:**	Glomerular Filtration Rate

HD	:	Hemodialysis
HES	:	Hydroxyethyl starches
HF	:	Hemofiltration
HIT	:	Heparin-induced thrombocytopenia
HVHF	:	High volume hemofiltration
ICU	:	Intensive care unit
IHD	:	Intermittent hemodialysis
MAP	:	Mean arterial pressure
MODS	:	Multiple-organ dysfunction syndrome
NAC	:	N-Acetylcysteine
NSAIDs	:	Non-steroidal anti-inflammatory drugs
PAN	:	Polyacrylonitrile membranes
PCr	:	Plasma Creatinine
PCT	:	Proximal convoluted tubule
PNa	:	Plasma Na
Purea	:	Plasma urea
RCA	:	Regional citrate anticoagulation
RCT	:	Randomized controlled trial
RIFLE	:	Risk-Injury-Failure-Loss-End
RO	:	Reverse osmosis
RRT	:	Renal replacement therapy
SAFE	:	Saline vs. Albumin Evaluation trial
SCUF	:	Slow continuous ultrafiltration
SIRS	:	Systemic inflammatory response syndrome
UCr	:	Urine Creatinine
UFH	:	Unfractionated heparin
UFR	:	Ultrafiltration rate
UNa	:	Urine Na
Uurea	:	Urine urea
Vd	:	Volume of distribution

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Introduction

The kidneys are a pair of organs located in the back of the abdomen. Each kidney is about 4 or 5 inches long, about the size of a fist. The kidneys' functions are to filter the blood (All the blood in our body's passes through the kidneys several times a day), remove wastes, control the body's fluid balance and regulate the balance of electrolytes. As the kidneys filter blood, they create urine, which collects in the kidneys' pelvis. Each kidney contains around a million units called nephrons, each of which is a microscopic filter for blood **(Brenner and Rector, 2007).**

Acute kidney injury (AKI) is defined as an abrupt (within 48 hours) reduction in kidney function. The AKI network defines the reduction in kidney function as the presence of any one of the following: An absolute increase in serum creatinine of $\geq$ 0.3 mg/dl, percentage increase in serum creatinine of $\geq$ 50% (1.5 fold from baseline) which is known or presumed to have occurred within the prior 7 days and reduction in urine output (< 0.5 ml/kg / hour for more than six hours) **(Mehta et al., 2007).**

Hemofiltration is a convective form of therapy usually involving plasma water removal and replacement. Commonly prescribed and applied continuously **(Martin and Ian, 2010).**

Hemofiltration is used for treatment of severe sepsis, septic shock and acute renal failure in haemodynamically unstable patients (those with acute renal failure who cannot undergo intermittent dialysis therapy) **(Grzegorz et al., 2011).**

Experimental studies have shown high volume hemofiltration can improve myocardial performance and systemic hemodynamics while also removing inflammatory cytokines **(Rimmele et al., 2009).**

It has been hypothesized that safety features and physiology of different renal replacement therapy (RRT) modalities delivered for AKI in critically ill patients might partially give explanation for different clinical outcomes such as mortality, recovery of renal function and dialysis independence. Continuous renal replacement therapy (CRRT) seems to represent the ideal therapy in order to physiologically restore renal homeostasis, steadily achieve adequate fluid balance, maintain hemodynamic stability and effectively control metabolic derangements of AKI and septic syndrome **(Vinsonneau et al., 2006).**

Human clinical studies mostly conducted in refractory septic shock have also shown that high volume hemofiltration (HVHF) can improve systemic hemodynamic and contribute to lower than expected mortality **(Vesconi et al., 2009).**

Anatomy of the kidney

Gross Features

The kidneys are a pair of retroperitoneal organs situated one on each side of the vertebral column. In the human, the upper pole of each kidney lies opposite the twelfth thoracic vertebra and the lower pole lies opposite the third lumbar vertebra .Because of compression by the liver the right kidney tends to be somewhat shorter and wider **(James and Jeffrey, 2011).**

The weight of each kidney ranges from 125 to 170 gm. in the adult male and from 115 to155 gm. in the adult female. The human kidney is approximately 11 to 12 cm in length, 5.0 to 7.5 cm in width and 2.5 to 3.0 cm in thickness. Located on the medial or concave surface of each kidney is a slit called the hilum through which the renal pelvis, the renal artery and vein, the lymphatic and a nerve plexus pass into the sinus of the kidney. The organ is surrounded by a thin tough fibrous capsule which is smooth and easily removable under normal conditions **(Robert et al., 2011).**

Microscopic features

Two distinct regions can be identified on the cut surface of a bisected kidney: a pale outer region (the cortex), and a darker inner region (the medulla). In humans, the medulla is divided into 8 to 18 striated conical masses (the renal pyramids) as shown in (figure1). The base of each pyramid is positioned at the corticomedullary boundary, and the apex extends toward the renal pelvis to form a papilla. On the tip of each papilla are 10 to 25 small openings that represent the distal ends of the collecting ducts (ducts of Bellini). These openings form the area cribrosa **(Robert et al., 2011).**

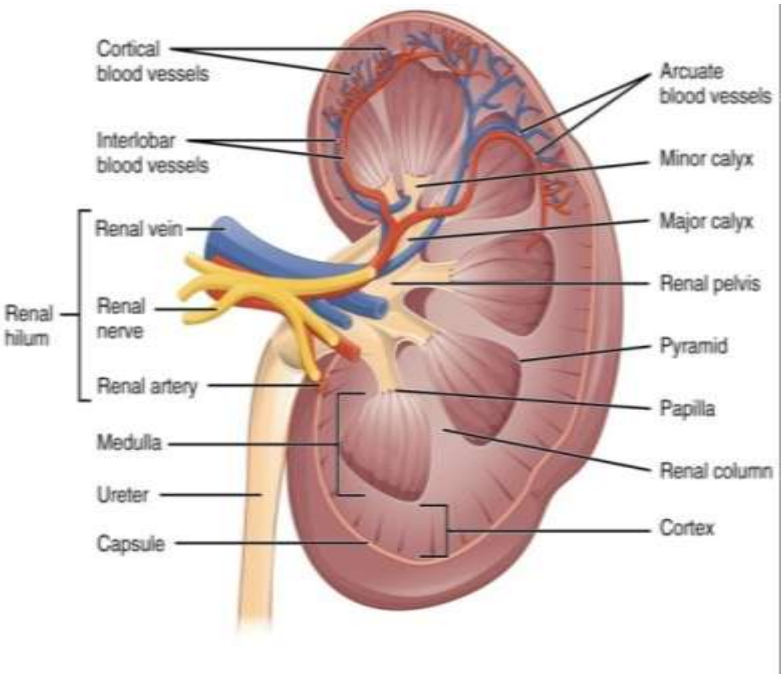

Figure 1: Diagram of the cut surface of a bisected kidney **(Robert et al., 2011).**

Nephron

The functional unit of the kidney is the nephron. Each human kidney contains about $0.6x10^6$ to $1.4x10^6$ nephrons. As shown in (figure 2) the components of the nephron include the glomerulus, Bowman’s capsule, the proximal tubule, the thin limbs, the distal tubule and the connecting tubule **(Robert et al., 2011).**

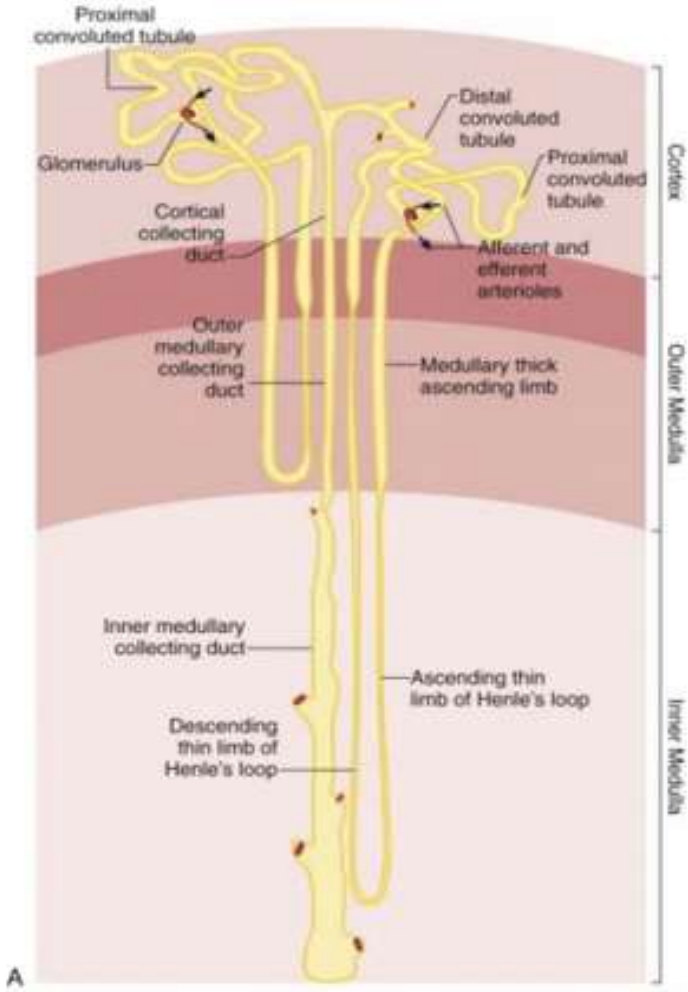

Figure 2: Structure of the nephron **(Qais and Jonathan, 2011).**

Microvasculature

The renal artery after entering the renal sinus finally divides into the interlobar arteries, which extend toward the cortex in the space between the wall of the pelvis (or calyx) and the adjacent cortical tissue. At the junction between cortex and medulla, the interlobar arteries divide arcuate arteries give rise to the cortical radial arteries (interlobular arteries), which ascend radially through the cortex as shown in (figure3), No arteries penetrate the medulla. Afferent arterioles supply the glomerular tufts and generally arise from cortical radial arteries. Glomerular tributaries to the capillary plexus are rarely found. As a result, the blood supply of the peritubular capillaries of the cortex and the medulla is exclusively postglomerular. Glomeruli are drained by efferent arterioles **(Inscho, 2009).**

Two basic types of efferent arterioles can be distinguished, cortical and juxtamedullary. Cortical efferent arterioles, which derive from superficial and mid cortical glomeruli, supply the capillary plexus of the cortex. The efferent arterioles of juxtamedullary glomeruli represent the supplying vessels of the renal medulla. Within the outer stripe of the medulla, these vessels divide into the descending vasa recta and then penetrate the inner stripe in cone-shaped vascular bundles. At intervals, individual vessels leave the bundles to supply the capillary plexus at the adjacent medullary level **(Inscho, 2009).**

Ascending vasa recta drain the renal medulla. In the inner medulla, the vasa recta arise at every level, ascending as unbranched vessels, and traverse the inner stripe within the vascular bundles (figure 3). The ascending vasa recta that drain the inner stripe may join the vascular bundles or may ascend directly to the outer stripe between the bundles.