Chapter One

Introduction

1.1Introduction

1.1.1The Kidney:

Kidneys are a bean shape organs that lie in a retroperitoneal position in the superior lumbar region extending approximately from T12 to L3. Each kidney comprises an outer cortex and an inner medulla. (snell 2012)

The kidney participates in whole-body homeostasis, regulating acid-base balance, electrolyte concentrations, extracellular fluid volume, and blood pressure.

The kidneys excrete a variety of waste products produced by metabolism into the urine. These include the nitrogenous wastes urea, from protein catabolism, and uric acid, from nucleic acid metabolism. This requires several independent nephron characteristics to operate: a tight hairpin configuration of the tubules, water and ion permeability in the descending limb of the loop, water impermeability in the ascending loop, and active ion transport out of most of the ascending limb. (Elaine N. 2004)

1.1.2GFR (Glomerular Filtration Rate):

Glomerular filtration rate (GFR) is the volume of fluid filtered from the renal (kidney) glomerular capillaries into the Bowman's capsule per unit time.The GFR, about 125 mL/min (180 liters/day),

Glomerular filtration rate (GFR) can be calculated by measuring any chemical that has a steady level in the blood, and is freely filtered but neither reabsorbed nor secreted by the kidneys. The rate therefore measured is the quantity of the substance in the urine that originated from a calculable volume of blood. The GFR is typically recorded in units of volume per time, e.g., milliliters per minute ml/min.

$$\mathrm{GFR} = \frac{\text{urine concentration} \times \text{urine flow}}{\text{plasma concentration}}$$

There are several different techniques used to calculate or estimate the glomerular filtration rate (GFR or eGFR)

1.1.3Renography

A renogram is simply a time-activity curve that provides a graphic representation of the uptake and excretion of a radiopharmaceutical by the kidneys. Information is displayed from the time of injection to about 20 to 30 minutes after injection. The classic renogram curve is obtained by using agents that are eliminated by glomerular filtration (e.g., 99mTc- DTPA). Renogram curves are generated by placing a region of interest around each kidney, usually the entire kidney, but occasionally just around the renal cortex if a considerable amount of collecting system activity is present. Background subtraction regions of interest are selected just inferior to eachkidney ,An aortic region of interest may be used to assess the discreteness and adequacy of the injected bolus as well as relative renal perfusion.The normal computer-generated renogramcurve using a glomerular radiopharmaceutical consists of three phases Initial renal perfusion, or the vascular transit phase, lasts about 30 to 60 seconds and represents the initial arrival of the radiopharmaceutical in each kidney. Reconstruction of the first 30 to 60 seconds of the curve by using different axes may be performed to assess more carefully the renal perfusion phase. Generally, renal peak activity during the perfusion phase equals or exceeds that of the aorta and should be reasonably symmetric between the two kidneys. The second phase is the function phase of initial parenchymal transit. This phase occurs during minutes 1 through 5 and contains the peak of the curve. The initial uptake slope closely correlates with GFR values. The third phase is the clearance or excretion phase, which represents the down slope of the curve and is produced by excretion of the radiopharmaceutical from the kidney and clearance from the collecting system. (Kazuo 2003).

1.1.4Creatinine Clearance CCr:

One method of determining GFR from creatinine is to collect urine (usually for 24-hours) to determine the amount of creatinine that was removed from the blood over a given time interval. If one removes, say, 1440 mg in 24 hours, this is equivalent to removing 1 mg/min. If the blood concentration is 0.01 mg/mL (1 mg/dL), then one can say that 100 mL/min of blood is being "cleared" of creatinine, since, to get 1 mg

of creatinine, 100 mL of blood containing 0.01 mg/mL would need to have been cleared.

Creatinine clearance (CCr) is calculated from the creatinine concentration in the collected urine sample (UCr), urine flow rate (V), and the plasma concentration (PCr). Since the product of urine concentration and urine flow rate yields creatinine excretion rate, which is the rate of removal from the blood, creatinine clearance is calculated as removal rate per min (UCr×V) divided by the plasma creatinine concentration. This is commonly represented mathematically as

$$\mathrm{Ccr} = \frac{\mathrm{Ucr} \times \mathrm{V}}{\mathrm{Pcr}}$$

The common procedure involves undertaking a 24-hour urine collection, from empty-bladder one morning to the contents of the bladder the following morning, with a comparative blood test then taken. The urinary flow rate is still calculated per minute, hence:

$$\mathrm{Ccr} = \frac{\text{Urine creatinine} \times \text{urine volume in 24 hours}}{\text{Plasma creatinine} \times 24 \times 60\text{mins}}$$

To allow comparison of results between people of different sizes, the CCr is often corrected for the body surface area (BSA) and expressed compared to the average sized man as mL/min/1.73 m2. While most adults have a BSA that approaches 1.7 (1.6-1.9), extremely obese or slim patients should have their CCr corrected for their actual BSA.

$$\mathrm{Ccr} - \text{corrected} = \frac{\mathrm{Ccr} \times 1.73}{\mathrm{BSA}}$$

BSA can be calculated on the basis of weight and height.

The creatinine clearance is not widely done any more, due to the difficulty in assuring a complete urine collection. When doing such a determination, to assess the adequacy of a complete collection, one always calculates the amount of creatinine excreted over a 24-hour period. This amount varies with muscle mass, and is higher in young people vs. old, in blacks vs. whites, and in men vs. women. An unexpectedly low or high 24-hour creatinine excretion rate voids the test. Nevertheless, in cases where estimates of creatinine clearance from serum creatinine are unreliable, creatinine clearance remains a useful test. These cases include

"estimation of GFR in individuals with variation in dietary intake (vegetarian diet, creatinine supplements) or muscle mass (amputation, malnutrition, muscle wasting), since these factors are not specifically taken into account in prediction equations. (Kazuo 2003).

1.2 Problem of the Study:

There are many methods to determine GFR such as: the estimation using the creatinine clearance, Tc^{99m} DTPA renography and plasma sample method. Justification of Tc^{99m} DTPA renography requires the results to be very accurate and reliable thus evaluation is needed to confirm the reliability and justification.

1.3 Objectives of the study:

General objective:

The general objective of this study is to evaluate the GFR that is determined by Tc^{99m} DTPA renography using creatinine clearance rate as a reference.

Specific objectives:

- To determine the GFR using renal scintigraphy and creatinine clearance.
- To compare between the renal scintigraphyusing Tc^{99m}DTPA renoghraphyandcreatinine clearance.
- To find the effect of patient age on the total GFR.
- To find the effect of body mass index on total GFR.

1.4Significant of the study:

To stand that renography is inexpendable and justified being accurate and reliable.

1.5Overview of the study:

This study will be consisting of five chapters. Chapter one will deals with the introduction, problem of the study, objectives,Significant of the study and thesis over view. Chapter two

will highlights the literature review related to the title of the study. Chapter three will shows the method and material used in this study. Chapter four will deals with the results and finally chapter five will include the discussion. Conclusion,recommendation, references and appendices.

Chapter Two

Literature review and previous studies

2.1Literature review

2.1.1Anatomy:

The bean-shaped kidneys lie in a retroperitoneal position in the superior lumbar region. Extending approximately from T12 to L3, The right kidney is crowded by the liver and lies slightly lower than the left. An adult's kidney has a mass of about 150 g (5 ounces) and its average dimensions are 12 cm long, 6 cm wide, and 3 cm thick. Each kidney comprises an outer cortex and an inner medulla.The lateral surface is convex. The medial surface is concave and has a vertical cleft called the renal hilum that leads into an internal space within the kidney called the renal sinus. The ureter, renal blood vessels, lymphatics, and nerves all join each kidney at the hilum and occupy the sinus. The kidney is supplied with oxygenated blood via the renal artery and drained of deoxygenated blood by the renal vein. In addition, urine produced by the kidney as part of its excretory function, drains out via narrow "tubules" called ureters, which in turn connected to the bladder.Atop each kidney is an adrenal (or suprarenal) gland, an endocrine gland that is functionally unrelated to the kidney.(snell 2012)

2.1.2 Physiology:

The kidney participates in whole-body homeostasis, regulating acid-base balance, electrolyte concentrations, extracellular fluid volume, and blood pressure. The kidney accomplishes these homeostatic functions both independently and in concert with other organs, particularly those of the endocrine system. Various endocrine hormones coordinate these endocrine functions; these include renin, angiotensin II, aldosterone, antidiuretic hormone, and atrial natriuretic peptide, and others.(Elaine N. 2004)

2.1.2.1 Reabsorption of vital nutrients:

Glucose at normal plasma levels is completely reabsorbed in the proximal tubule. The mechanism for this is the Na+/glucose transporter. A plasma level of 350 mg/dL will fully saturate the transporters and glucose will be lost in the urine. A plasma glucose level of approximately 160 is sufficient to allow glucosuria, which is an important clinical clue to diabetes mellitus.Amino acids are reabsorbed by sodium dependent transporters in the proximal tubule. (Elaine N. 2004)

Location ofRe-absorption	Reabsorbed nutrient	Notes
Early proximal tubule	Glucose (100%), amino acids (100%), bicarbonate (90%), Na^+ (65%), Cl^-, phosphate and H_2O (65%)	- PTH will inhibit phosphate excretion. - AT II stimulates Na^+, H_2O and HCO_3^-reabsorption.
Thin descending loop of Henle	H_2O	-Reabsorbs via medullary hyper tonicity and makes urine hypertonic.
Thick ascending loop of Henle	Na^+(10–20%), K^+, Cl^-; indirectly induces para cellular reabsorption of Mg^{2+}, Ca^{2+}	-This region is impermeable to H_2O and the urine becomes less concentrated as it ascends.
Early distal convoluted tubule	Na^+, Cl^-	-PTH causes Ca^{2+} reabsorption.
Collecting tubules	Na^+(3–5%), H_2O	-Na^+ is reabsorbed in exchange for K^+,, and H^+, which is regulated by aldosterone. -ADH acts on the V2 receptor and inserts aquaporins on the luminal side

2.1.2.2 Acid-base homeostasis:

Two organ systems, the kidneys and lungs, maintain acid-base homeostasis, which is the maintenance of pH around a relatively stable value. The lungs contribute to acid-base homeostasis by regulating carbon dioxide (CO_2 concentration. The kidneys have two very

important roles in maintaining the acid-base balance: to reabsorb and regenerate bicarbonate from urine, and to excrete hydrogen ions and fixed acids (anions of acids) into urine.(Elaine N. 2004)

2.1.2.3 Excretion of wastes:

The kidneys excrete a variety of waste products produced by metabolism into the urine. These include the nitrogenous wastes urea, from protein catabolism, and uric acid, from nucleic acid metabolism. The ability of mammals and some birds to concentrate wastes into a volume of urine much smaller than the volume of blood from which the wastes were extracted is dependent on an elaborate countercurrent multiplication mechanism. This requires several independent nephron characteristics to operate: a tight hairpin configuration of the tubules, water and ion permeability in the descending limb of the loop, water impermeability in the ascending loop, and active ion transport out of most of the ascending limb. In addition, passive countercurrent exchange by the vessels carrying the blood supply to the nephron is essential for enabling this function.(Elaine N. 2004)

2.1.2.4 Osmolality regulation:

Any significant rise in plasma osmolality is detected by the hypothalamus, which communicates directly with the posterior pituitary gland. An increase in osmolality causes the gland to secrete antidiuretic hormone (ADH), resulting in water reabsorption by the kidney and an increase in urine concentration. The two factors work together to return the plasma osmolality to its normal levels.

ADH binds to principal cells in the collecting duct that translocate aquaporins to the membrane, allowing water to leave the normally impermeable membrane and be reabsorbed into the body by the vasa recta, thus increasing the plasma volume of the body.

There are two systems that create a hyperosmotic medulla and thus increase the body plasma volume: Urea recycling and the 'single effect.'

Urea is usually excreted as a waste product from the kidneys. However, when blood plasma volume is low and ADH is released the aquaporins that are opened are also permeable to urea.

This allows urea to leave the collecting duct into the medulla creating a hyperosmotic solution that 'attracts' water. Urea can then re-enter the nephron and be excreted or recycled again depending on whether ADH is still present or not.

The 'Single effect' describes the fact that the ascending thick limb of the loop of Henle is not permeable to water but is permeable to NaCl. This allows for a countercurrent exchange system whereby the medulla becomes increasingly concentrated, but at the same time setting up an osmotic gradient for water to follow should the aquaporins of the collecting duct be opened by ADH.(Elaine N. 2004)

2.1.2.5 Blood pressure regulation:

Although the kidney cannot directly sense blood, long-term regulation of blood pressure predominantly depends upon the kidney. This primarily occurs through maintenance of the extracellular fluid compartment, the size of which depends on the plasma sodium concentration. Renin is the first in a series of important chemical messengers that make up the renin-angiotensin system. Changes in renin ultimately alter the output of this system, principally the hormones angiotensin II and aldosterone. Each hormone acts via multiple mechanisms, but both increase the kidney's absorption of sodium chloride, thereby expanding the extracellular fluid compartment and raising blood pressure. When renin levels are elevated, the concentrations of angiotensin II and aldosterone increase, leading to increased sodium chloride reabsorption, expansion of the extracellular fluid compartment, and an increase in blood pressure. Conversely, when renin levels are low, angiotensin II and aldosterone levels decrease, contracting the extracellular fluid compartment, and decreasing blood pressure.(Elaine N. 2004)

2.1.2.6 Hormone secretion:

The kidneys secrete a variety of hormones, including erythropoietin, and the enzyme renin. Erythropoietin is released in response to hypoxia (low levels of oxygen at tissue level) in the renal circulation. It stimulates erythropoiesis (production of red blood cells) in the bone

marrow. Calcitriol, the activated form of vitamin D, promotes intestinal absorption of calcium and the renal reabsorption of phosphate. Part of the renin–angiotensin–aldosterone system, renin is an enzyme involved in the regulation of aldosterone levels.(Elaine N. 2004)

2.1.3Nephron:

The kidney consists of over a million individual filtering units called nephrons. Each **nephron** consists of a filtering bodytherenal corpuscle, and a urine-collecting and concentrating tube the renal tubule. (Elaine N. 2004)

2.1.3.1 Renal Capsule*:*

The renal capsule is the part of the kidney nephron in which blood plasma is filtered.

The term "capsule" means "tiny" or "small" body. The renal capsule of each kidney nephron has two parts - they are the Glomerulus which is a network of small blood vessels called capillaries, and the Bowman's Capsule (also known as the Glomerular Capsule), which is the double-walled epithelial cup within which the glomerulus is contained.

Within the glomerulus are glomerular capillaries that are located between the afferent arteriole bringing blood into the glomerulus and the efferent arteriole draining blood away from the glomerulus. The (outgoing) efferent arteriole has a smaller diameter than the (incoming) afferent arteriole. This difference in arteriole diameters helps to raise the blood pressure in the glomerulus.

The area between the double-walls of the Bowman's Capsule is called the capsular space. The cells that form the outer edges of the glomerulus form close attachments to the cells of the inner surface of the Bowman's Capsule. This combination of cells adhered to each other forms a filtration membrane that enables water and solutes (substances that are dissolved in the water/blood) to pass through the first wall of the Bowman's Capsule into the capsular space. This filtration process is helped by the raised blood pressure in the glomerulus - due to the difference in diameter of the afferent and efferent arterioles.(Elaine N. 2004)

2.1.3.2Renal Tubule:

The renal tubule is the part of the kidney nephron into which the glomerular filtrate passes after it has reached the Bowman's capsule. The first part of the renal tubule is called the **proximal convoluted tubule (PCT)**,The water and solutes that have passed through the proximal convoluted tubule (PCT) enter the Loop of Henle, which consists of two portions - first the descending limb of Henle, then the ascending limb of Henle. In order to pass through the Loop of Henle, the water (and substances dissolved in it) pass from the renal cortex into the renal medulla, then back to the renal cortex.

When this fluid returns to the renal cortex (via the ascending limb of Henle) it passes into the **distal convoluted tubule (DCT) ,**The distal convoluted tubules of many individual kidney nephrons converge onto a single collecting duct.

The fluid that has passed through the distal convoluted tubules is drained into the collecting duct (far left-hand-side of the diagram above). Many collecting ducts join together to form several hundred papillary ducts. There are typically about 30 papillary ducts per renal papilla (the renal papillae being the tips of the renal pyramids - which point towards the Centre of the kidney). At each renal papilla the contents of the papillary ducts drain into the minor calces - the channels through which the fluid passes, via the major calyx, into the Centre of the kidney - called the renal pelvis.

The operation of the human nephron consists of three processes:

Glomerular filtration
Tubular reabsorption
Tubular secretion

These three processes, which determine the quantity and quality of the urine.

2.1.3.3Glomerular filtration:

The first step in the production of urine is called glomerular filtration. Filtration (the foreign of fluids and dissolved substances through a membrane by pressure) occurs in Bowman’s capsule when blood enters the glomerular, the blood pressure forces water and dissolved components through the endothelial pores of the capillaries, basement membrane and through the filtration slits of the adjoining visceral wall of the glomerular (Bowman’s capsule). The

resulting fluid is called the filtrate. In healthy person, the filtrates consist of all the blood accepts for the formed elements and most proteins, which are too large to pass through the endothelial – capsular barrier.

2.1.3.4Tubular reabsorption:

In healthy kidneys, nearly all of the desirable organic substances (proteins, amino acids, glucose) are reabsorbed by the cells that line the renal tube. These substances then move into the peritubular capillaries that surround the tubule. Most of the water and many ions are reabsorbed as well, but the amounts are regulated so that blood volume, pressure, and ion concentration are maintained within required levels for homeostasis.

Reabsorbed substances move from the lumen of the renal tubule to the lumen of a peritubular capillary. Movement of substances out of the tubule, then, must occur through the cells, either by active transport (requiring ATP) or by passive transport processes.

Once outside of the tubule and in the interstitial fluids, substances move into the peritubular capillaries or vasa recta by passive processes.

The reabsorption of most substances from the tubule to the interstitial fluids requires a membrane-bound transport protein that carries these substances across the tubule cell membrane by active transport. When all of the available transport proteins are being used, the rate of reabsorption reaches a transport maximum (Tm), and substances that cannot be transported are lost in the urine.

The following mechanisms direct tubular reabsorption in the indicated regions:

- Active transport of Na^+(in the PCT, DCT, and collecting duct). Because Na^+ concentration is low inside tubular cells, Na^+enters the tubular cells (across the luminal membrane) by passive diffusion. At the other side of the tubule cells, the basolateral membrane bears proteins that function as sodium-potassium (Na^+-k^+) pumps. These pumps use ATP to simultaneously export Na^+while importingk^+. Thus, Na^+in the tubule cells is transported out of the cells and into the interstitial fluid by active transport. The Na^+in the interstitial fluid then enters the capillaries by passive diffusion. (The k^+that is transported into the cell leaks back passively into the interstitial fluid.)
- Symporter transport (secondary active transport) of nutrients and ions (in the PCT and nephron loop). Various nutrients, such as glucose and amino acids, and certain ions

($k^+$and Cl^-) in the thick ascending limb of the nephron loop are transported into the tubule cells by the action of Na^+symporters. A Na^+symporter is a transport protein that carries both $Na^+$and another molecule, such as glucose, across a membrane in the same direction. Movement of glucose and other nutrients from the tubular lumen into the tubule cells occurs in this fashion. The process requires a low concentration of Na^+inside the cells, a condition maintained by the Na^+-k^+pump operating on the basolateral membranes of the tubule cells. The movement of nutrients into cells by this mechanism is referred to as secondary active transport, because the ATP-requiring mechanism is the Na^+-k^+pumand not the symporter itself. Once inside the tubular cells, nutrients move into the interstitial fluid and into the capillaries by passive processes.

- Passive transport of H_2O by osmosis (in the PCT and DCT). The buildup of Na^+in the peritubular capillaries creates a concentration gradient across which water passively moves, from tubule to capillaries, by osmosis. Thus, the reabsorption of $Na^+$by active transport generates the subsequent reabsorption of H_2O by passive transport, a process called obligatory H_2O reabsorption.
- Passive transport of various solutes by diffusion (in the PCT and DCT, and collecting duct). As H_2O moves from the tubule to the capillaries, various solutes such as k^+, Cl^-, HCO_3^-, and urea become more concentrated in the tubule. As a result, these solutes follow the water, moving by diffusion out of the tubule and into capillaries where their concentrations are lower, a process called solvent drag. Also, the accumulation of the positively charged Na^+in the capillaries creates an electrical gradient that attracts (by diffusion) negatively charged ions (Cl^-, HCO_3^-).
- $H_2O$and solute transport regulated by hormones (in the DCT and collecting duct). The permeability of the DCT and collecting duct and the resultant reabsorption of H_2O and $Na^+$are controlled by two hormones
- Aldosterone increases the reabsorption of $Na^+$and $H_2O$by stimulating an increase in the number of Na^+-k^+pump proteins in the principal cells that line the DCT and collecting duct.
- Antidiuretic hormone (ADH) increases H_2O reabsorption by stimulating an increase in the number of H_2O-channel proteins in the principal cells of the collecting duct.

2.1.3.5Tubular Secretion:

- In contrast to tubular reabsorption, which returns substances to the blood, tubular secretion removes substances from the blood and secretes them into the filtrate. Secreted substances include H^+, k^+, $NH_4{}^+$ (ammonium ion), creatinine (a waste product of muscle contraction), and various other substances (including penicillin and other drugs). Secretion occurs in portions of the PCT, DCT, and collecting duct.
- Secretion of H^+. Because a decrease in H^+ causes a rise in pH (a decrease in acidity), H^+ secretion into the renal tubule is a mechanism for raising blood pH. Various acids produced by cellular metabolism accumulate in the blood and require that their presence be neutralized by removing H^+.

  In addition, CO_2, also a metabolic byproduct, combines with water (catalyzed by the enzyme carbonic anhydrase) to produce carbonic acid (H_2CO_3), which dissociates to produce H^+.
- This chemical reaction occurs in either direction (it is reversible) depending on the concentration of the various reactants. As a result, if $HCO_3{}^-$ increases in the blood, it acts as a buffer of H^+, combining with it (and effectively removing it) to produceCO_2 and H_2O. CO_2in tubular cells of the collecting duct combines with $H_2O$to form $H^+$and $HCO_3{}^-$The CO_2 may originate in the tubular cells or it may enter these cells by diffusion from the renal tubule, interstitial fluids, or peritubular capillaries. In the tubule cell, Na^+/H^+ antiporters, enzymes that move transported substances in opposite directions, transport H^+ across the luminal membrane into the tubule while importing Na^+. Inside the tubule, H + may combine with any of several buffers that entered the tubule as filtrate ($HCO_3{}^-$, NH_3, or $HPO_4{}^{2-}$). If $HCO_3{}^-$is the buffer, then H_2CO_3 is formed, producing $H_2O$and CO_2. The CO_2then enters the tubular cell, where it can combine with H_2O again. If H^+combines with another buffer, it is excreted in the urine. Regardless of the fate of the H^+ in the tubule, the $HCO_3{}^-$produced in the first step is transported across the basolateral membrane by an$HCO_3{}^-/Cl^-$ antiporter. The $HCO_3{}^-$enters the peritubular capillaries, where it combines with the H^+ in the blood and increases the blood pH. Note that the blood pH is increased by adding $HCO_3{}^-$to the blood, not by removing H^+.
- Secretion of NH_3. When amino acids are broken down, they produce toxic NH_3. The liver converts most NH_3 to urea, a less toxic substance. Both enter the filtrate during

glomerular filtration and are excreted in the urine. However, when the blood is very acidic, the tubule cells break down the amino acid glutamate, producing NH_3. AndHCO_3^-. The NH_3. Combines with H^+,formingNH_4^+, which is transported across the luminal membrane by a Na + antiporter and excreted in the urine. The HCO_3^-moves to the blood (as discussed earlier for H^+secretion) and increases blood pH.

- Secretion of k^+Nearly all of the k^+in filtrate is reabsorbed during tubular reabsorption. When reabsorbed quantities exceed body requirements, excess $k^+$is secreted back into the filtrate in the collecting duct and final regions of the DCT. Because aldosterone stimulates an increase inNa^+/k^+pumps, k^+secretion (as well as Na^+ reabsorption) increases with aldosterone.

2.1.3.6Mechanism of urine concentration:

The excretion of concentration urine begins with high concentration of solutes in the interstitial fluid in the medulla of the kidney the high medulary concentration is ma is maintained by two principal factors include: Solutes reabsorption from various parts of the renal tubules , Countercurrent mechanism which based on the anatomical arrangement of the juxtamedullary nephrons and vasarecta.

Urine is expelled from the urinary bladder by an act called micturition, commonly known as urination or voiding. This response is brought about by a combination of involuntary and voluntary nerve impulses. The average capacity of the urinary bladder exceed 200 to 400ml, stretch receptors in the urinary bladder wall transmit impulses to the lower portion of the spinal cord. These impulses, by way of sensory tracts to the cortex, initiate a conscious desire to expel urine and, by way of a center in the sacral cord, a subconscious reflex referred to as the micturition reflex. Parasympathetic impulses transmitted from the micturition reflex center of the sacral area of the spinal cord reach the urinary bladder wall and internal urethral sphincter, bringing about contraction of the detrusor muscle of the urinary bladder and relaxation of the internal sphincter. Then the conscious portion of the brain sends impulses to the external sphincter, the sphincter relaxes, and urination takes place. Although emptying the urinary bladder is controlled by reflex, it may be initiated voluntarily and stopped at will because of cerebral control of external sphincter and certain muscles of the urogenital (Pelvic) diaphragm.

Renal function, in nephrology, is an indication of the state of the kidney and its role in renal physiology. Glomerular filtration rate (GFR) describes the flow rate of filtered fluid through the kidney. Creatinine clearance rate (CCr or CrCl) is the volume of blood plasma that is cleared of creatinine per unit time and is a useful measure for approximating the GFR. Creatinine clearance exceeds GFR due to creatinine secretion, which can be blocked by cimetidine. In alternative fashion, overestimation by older serum creatinine methods resulted in an underestimation of creatinine clearance, which provided a less biased estimate of GFR. Both GFR and CCr may be accurately calculated by comparative measurements of substances in the blood and urine, or estimated by formulas using just a blood test result (eGFR and eCCr).

Most doctors use the plasma concentrations of the waste substances of creatinine and urea (U), as well as electrolytes (E), to determine renal function. These measures are adequate to determine whether a patient is suffering from kidney disease.

However, blood urea nitrogen (BUN) and creatinine will not be raised above the normal range until 60% of total kidney function is lost. Hence, the more accurate Glomerular filtration rate or its approximation of the creatinine clearance is measured whenever renal disease is suspected or careful dosing of nephrotoxic drugs is required.Elevated protein levels in urine mark some kidney disease. The most sensitive marker of proteinuria is elevated urine albumin. Persistent presence of more than 30 mg albumin per gram creatinine in the urine is diagnostic of chronic kidney disease .

2.1.4. GFR (Glomerular Filtration Rate) :

Glomerular filtration rate (GFR) is the volume of fluid filtered from the renal (kidney) glomerular capillaries into the Bowman's capsule per unit time.The GFR, about 125 mL/min (180 liters/day), is regulated by the following:

- Renal auto regulation is the ability of the kidney to maintain a constant GFR even when the body's blood pressure fluctuates. Auto regulation is accomplished by cells in the juxtaglomerular apparatus that decrease or increase secretion of a vasoconstrictor substance that dilates or constricts, respectively, the afferent arteriole.

-Neural regulation of GFR occurs when vasoconstrictor fibers of the sympathetic nervous system constrict afferent arterioles. Such stimulation may occur during exercise, stress, or other fight-or-flight conditions and results in a decrease in urine production.

-Hormonal control of GFR is accomplished by the renin/angiotensinogen mechanism. When cells of the juxtaglomerular apparatus detect a decrease in blood pressure in the afferent arteriole or a decrease in solute (Na + and Cl –) concentrations in the distal tubule, they secrete the enzyme renin.

Renin converts angiotensinogen (a plasma protein produced by the liver) to angiotensin I. Angiotensin I in turn is converted to angiotensin II by the angiotensin-converting enzyme (ACE), an enzyme produced principally by capillary endothelium in the lungs. Angiotensin II circulates in the blood and increases GFR by doing the following:

-Constricting blood vessels throughout the body, causing the blood pressure to rise

-Stimulating the adrenal cortex to secrete aldosterone, a hormone that increases blood pressure by decreasing water output by the kidneys.

Glomerular filtration rate (GFR) can be calculated by measuring any chemical that has a steady level in the blood, and is freely filtered but neither reabsorbed nor secreted by the kidneys. The rate therefore measured is the quantity of the substance in the urine that originated from a calculable volume of blood. The GFR is typically recorded in units of volume per time, e.g., milliliters per minute ml/min.

$$\mathrm{GFR} = \frac{\text{urine concentration} \times \text{urine flow}}{\text{plasma concentration}}$$

There are several different techniques used to calculate or estimate the glomerular filtration rate (GFR or eGFR) :

2.1.4.1.Renography:

A renogram is simply a time-activity curve that provides a graphic representation of the uptake and excretion of a radiopharmaceutical by the kidneys. Information is displayed from the time of injection to about 20 to 30 minutes after injection. The classic renogram curve is obtained by using agents that are eliminated by glomerular filtration (e.g., 99mTc- DTPA). Renogram curves are generated by placing a region of interest around each kidney, usually the entire kidney, but occasionally just around the renal cortex if a considerable amount of collecting system activity is present. Background subtraction regions of interest are selected

just inferior to eachkidney ,An aortic region of interest may be used to assess the discreteness and adequacy of the injected bolus as well as relative renal perfusion.The normal computer-generated renogramcurve using a glomerular radiopharmaceutical consists of three phases Initial renal perfusion, or the vascular transit phase, lasts about 30 to 60 seconds and represents the initial arrival of the radiopharmaceutical in each kidney. Reconstruction of the first 30 to 60 seconds of the curve by using different axes may be performed to assess more carefully the renal perfusion phase. Generally, renal peak activity during the perfusion phase equals or exceeds that of the aorta and should be reasonably symmetric between the two kidneys. The second phase is the function phase of initial parenchymal transit. This phase occurs during minutes 1 through 5 and contains the peak of the curve. The initial uptake slope closely correlates with GFR values. The third phase is the clearance or excretion phase, which represents the down slope of the curve and is produced by excretion of the radiopharmaceutical from the kidney and clearance from the collecting system. (Kazuo 2003).

2.1.4.2. Measurement using inulin:

The GFR can be determined by injecting inulin into the plasma. Since inulin is neither reabsorbed nor secreted by the kidney after glomerular filtration, its rate of excretion is directly proportional to the rate of filtration of water and solutes across the glomerular filter. Compared to the MDRD formula, the inulin clearance slightly overestimates the glomerular function. In early stage renal disease, the inulin clearance may remain normal due to hyperfiltration in the remaining nephrons. Incomplete urine collection is an important source of error in inulin clearance measurement.(Kazuo 2003).

2.1.4.3.Creatinine-based approximations of GFR:

In clinical practice, however, creatinine clearance or estimates of creatinine clearance based on the serum creatinine level are used to measure GFR. Creatinine is produced naturally by

the body (creatinine is a break-down product of creatinine phosphate, which is found in muscle). It is freely filtered by the glomerular, but also actively secreted by the peritubular capillaries in very small amounts such that creatinine clearance overestimates actual GFR by 10-20%. This margin of error is acceptable, considering the ease with which creatinine clearance is measured. Unlike precise GFR measurements involving constant infusions of inulin, creatinine is already at a steady-state concentration in the blood, and so measuring creatinine clearance is much less cumbersome. However, creatinine estimates of GFR have their limitations. All of the estimating equations depend on a prediction of the 24-hour creatinine excretion rate, which is a function of muscle mass. One of the equations, the Cockcroft and Gault equation (see below) does not correct for race, and it is known that African Americans, for example, both men and women, have a higher amount of muscle mass than Caucasians; hence, African Americans will have a higher serum creatinine level at any level of creatinine clearance.

A common mistake made when just looking at serum creatinine is the failure to account for muscle mass. Hence, an older woman with a serum creatinine of 1.4 may actually have a moderately severe degree of renal insufficiency, whereas a young muscular male, in particular if African American, can have a normal level of renal function at this serum creatinine level. Creatinine-based equations should be used with caution in cachectic patients and patients with cirrhosis. They often have very low muscle mass and a much lower creatinine excretion rate than predicted by the equations below, such that a cirrhotic patient with a serum creatinine of 0.9 may have a moderately severe degree of renal insufficiency.(Kazuo 2003).

2.1.4.4.Creatinine Clearance CCr:

One method of determining GFR from creatinine is to collect urine (usually for 24-hours) to determine the amount of creatinine that was removed from the blood over a given time interval. If one removes, say, 1440 mg in 24 hours, this is equivalent to removing 1 mg/min. If the blood concentration is 0.01 mg/mL (1 mg/dL), then one can say that 100 mL/min of blood is being "cleared" of creatinine, since, to get 1 mg of creatinine, 100 mL of blood containing 0.01 mg/mL would need to have been cleared.

Creatinine clearance (CCr) is calculated from the creatinine concentration in the collected urine sample (UCr), urine flow rate (V), and the plasma concentration

(PCr). Since the product of urine concentration and urine flow rate yields creatinine excretion rate, which is the rate of removal from the blood, creatinine clearance is calculated as removal rate per min (UCr×V) divided by the plasma creatinine concentration. This is commonly represented mathematically as

$$\mathrm{Ccr} = \frac{\mathrm{Ucr} \times \mathrm{V}}{\mathrm{Pcr}}$$

The common procedure involves undertaking a 24-hour urine collection, from empty-bladder one morning to the contents of the bladder the following morning, with a comparative blood test then taken. The urinary flow rate is still calculated per minute, hence:

$$\mathrm{Ccr} = \frac{\text{Urine creatinine} \times \text{urine volume in 24 hours}}{\text{Plasma creatinine} \times 24 \times 60\text{mins}}$$

To allow comparison of results between people of different sizes, the CCr is often corrected for the body surface area (BSA) and expressed compared to the average sized man as mL/min/1.73 m2. While most adults have a BSA that approaches 1.7 (1.6-1.9), extremely obese or slim patients should have their CCr corrected for their actual BSA.

$$\mathrm{Ccr} - \text{corrected} = \frac{\mathrm{Ccr} \times 1.73}{\mathrm{BSA}}$$

BSA can be calculated on the basis of weight and height.

The creatinine clearance is not widely done any more, due to the difficulty in assuring a complete urine collection. When doing such a determination, to assess the adequacy of a complete collection, one always calculates the amount of creatinine excreted over a 24-hour period. This amount varies with muscle mass, and is higher in young people vs. old, in blacks vs. whites, and in men vs. women. An unexpectedly low or high 24-hour creatinine excretion rate voids the test. Nevertheless, in cases where estimates of creatinine clearance from serum creatinine are unreliable, creatinine clearance remains a useful test. These cases include "estimation of GFR in individuals with variation in dietary intake (vegetarian diet, creatinine supplements) or muscle mass (amputation, malnutrition, muscle wasting), since these factors are not specifically taken into account in prediction equations.(Kazuo 2003).

2.1.4.5.A number of formulae have been devised to estimate GFR or Ccr values on the basis of serum creatininelevels :

Estimated creatinine clearance rate (eCCr) using Cockcroft-Gault formula :A commonly used surrogate marker for estimate of creatinine clearance is the Cockcroft-Gault formula, which in turn estimates GFR in mL/min: It is named after the scientists who first published the formula, and it employs serum creatinine measurements and a patient's weight to predict the creatinine clearance. The formula, as originally published, is:

$$\mathrm{eCcr} = \frac{(140 - \mathrm{Age}) \times \mathrm{Mass(in\ kilograms)} \times [0.85\ \mathrm{if\ female}]}{72 \times \mathrm{Serum\ Creatinine(in\ mg/dL)}}$$

This formula expects weight to be measured in kilograms and creatinine to be measured in mg/dL, as is standard in the USA. The resulting value is multiplied by a constant of 0.85 if the patient is female. This formula is useful because the calculations are simple and can often be performed without the aid of a calculator.

When serum creatinine is measured in μmol/L:

$$\mathrm{eCcr} = \frac{(140 - \mathrm{Age}) \times \mathrm{Mass(in\ kilograms)} \times \mathrm{Constant}}{\mathrm{Serum\ Creatinine\ (in\ \mu\ mole/L)}}$$

Where Constant is 1.23 for men and 1.04 for women.

One interesting feature of the Cockcroft and Gault equation is that it shows how dependent the estimation of CCr is based on age. The age term is (140 - age). This means that a 20-year-old person (140-20 = 120) will have twice the creatinine clearance as an 80-year-old (140-80 = 60) for the same level of serum creatinine (120 is twice as great as 60). The C-G equation also shows that a woman will have a 15% lower creatinine clearance than a man at the same level of serum creatinine.(Kazuo 2003).

Estimated GFR (eGFR) using Modification of Diet in Renal Disease (MDRD) formula : The most recently advocated formula for calculating the GFR is the one that was developed by the Modification of Diet in Renal Disease Study Group. Most laboratories in Australia and The United Kingdom now calculate and report the MDRD estimated GFR along with creatinine measurements and this forms the basis of chronic kidney disease and Staging. The adoption of the automatic reporting of MDRD-eGFR has been widely criticised.

The most commonly used formula is the "4-variable MDRD," which estimates GFR using four variables: serum creatinine, age, race, and gender. The original MDRD used six variables with the additional variables being the blood urea nitrogen and albumin levels. The equations have been validated in patients with chronic kidney disease; however both versions underestimate the GFR in healthy patients with GFRs over 60 mL/min. The equations have not been validated in acute renal failure.

For creatinine in mg/Dl

$$\text{eGFR} = 186 \times \text{Serum Creatinine}^{-1.154} \times \text{Age}^{-0.203} \times [1.212 \text{ if Black}] \times [0.742 \text{ if female}]$$

For creatinine in µmol/L:

$$eGFR = 32788 \times Serum\ Creatinine^{-1.154} \times Age^{-0.203} \times [1.212 \text{if Black}] \times [0.742 \text{iffemale}]$$

Creatinine levels in µmol/L can be converted to mg/dL by dividing them by 88.4. The 32788 number above is equal to $186 \times 88.4^{1.154}$.

A more elaborate version of the MDRD equation also includes serum albumin and blood urea nitrogen (BUN) levels:

$$\text{eGFR} = 170 \times \text{Serum Creatinine}^{-0.999} \times \text{Age}^{-0.176} \times [0.762 \text{ if female}] \times [1.180 \text{ if Black}] \times \text{BUN}^{-0.170} \times \text{Albumin}^{+0.318}$$

Where the creatinine and blood urea nitrogen concentrations are both in mg/dL. The albumin concentration is in g/dL.

These MDRD equations are to be used only if the laboratory has NOT calibrated its serum creatinine measurements to isotope dilution mass spectroscopy (IDMS). When IDMS-calibrated serum creatinine is used (which is about 6% lower), the above equations should be multiplied by 175/186 or by 0.94086.

Since these formulae do not adjust for body mass, they (relative to the Cockcroft-Gault formula) underestimate eGFR for heavy people and overestimate it for underweight people.(Julie 2003)

Estimated GFR (eGFR) using the CKD-EPI formula : The CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) formula was published in May 2009. It was developed in an effort to create a formula more accurate than the MDRD formula, especially when actual GFR is greater than 60 mL/min per 1.73 m2.

Researchers pooled data from multiple studies to develop and validate this new equation. They used 10 studies that included 8254 participants, randomly using 2/3 of the data sets for development and the other 1/3 for internal validation. Sixteen additional studies, which included 3896 participants, were used for external validation.

The CKD-EPI equation performed better than the MDRD (Modification of Diet in Renal Disease Study) equation, especially at higher GFR, with less bias and greater accuracy. When looking at NHANES (National Health and Nutrition Examination Survey) data, the median estimated GFR was 94.5 mL/min per 1.73 m2 vs. 85.0 mL/min per 1.73 m2, and the prevalence of chronic kidney disease was 11.5% versus 13.1%.

The CKD-EPI equation, expressed as a single equation, is:

$eGFR=141\times\min(SCr/k,1)^{\alpha}\times\max(SCr/k,1)^{-1.209}\times0.993^{Age}\times[1.018 iffemale]\times[1.159 if Black]$

Where SCr is serum creatinine (mg/dL), k is 0.7 for females and 0.9 for males, a is -0.329 for females and -0.411 for males, min indicates the minimum of SCr/k or 1, and max indicates the maximum of SCr/k or 1.

2.1.4.6.Cystatin C:

Problems with creatinine (varying muscle mass, recent meat ingestion, etc.) have led to evaluation of alternative agents for estimation of GFR. One of these is cystatin C, a ubiquitous protein secreted by most cells in the body (it is an inhibitor of cysteine protease).

Cystatin C is freely filtered at the glomerular. After filtration, Cystatin C is reabsorbed and catabolized by the tubular epithelial cells, with only small amounts excreted in the urine. Cystatin C levels are therefore measured not in the urine, but in the bloodstream.

Equations have been developed linking estimated GFR to serum cystatin C levels. Most recently, some proposed equations have combined creatinine and cystatin.

The normal range of GFR, adjusted for body surface area, is similar in men and women, and is in the range of 100-130 ml/min/1.73m2. In children, GFR measured by inulin clearance remains close to about 110 ml/min/1.73m2 down to about 2 years of age in both sexes, and then it progressively decreases. After age 40, GFR decreases progressively with age, by about 0.4 - 1.2 mL/min per year .

2.1.5 Pathology:

Pyelonephritis (infection of kidney pelvis): Bacteria may infect the kidney, usually causing back pain and fever. A spread of bacteria from an untreated bladder infection is the most common cause of pyelonephritis.(Kumar V. 2013)

Glomerulonephritis: An overactive immune system may attack the kidney, causing inflammation and some damage. Blood and protein in the urine are common problems that occur with glomerulonephritis. It can also result in kidney failure.(Kumar V. 2013)

Kidney stones (nephrolithiasis): Minerals in urine form crystals (stones), which may grow large enough to block urine flow. It's considered one of the most painful conditions. Most kidney stones pass on their own but some are too large and need to be treated.(Kumar V. 2013)

Nephrotic syndrome: Damage to the kidneys causes them to spill large amounts of protein into the urine. Leg swelling (edema) may be a symptom.(Kumar V. 2013)

Polycystic kidney disease: A genetic condition resulting in large cysts in both kidneys that impair their function.(Kumar V. 2013)

Acute renal failure (kidney failure): A sudden worsening in kidney function. Dehydration, a blockage in the urinary tract, or kidney damage can cause acute renal failure, which may be reversible.(Kumar V. 2013)

Chronic renal failure: A permanent partial loss of kidney function. Diabetes and high blood pressure are the most common causes.(Kumar V. 2013)

End stage renal disease (ESRD): Complete loss of kidney function, usually due to progressive chronic kidney disease. People with ESRD require regular dialysis for survival.(Kumar V. 2013)

Papillary necrosis: Severe damage to the kidneys can cause chunks of kidney tissue to break off internally and clog the kidneys. If untreated, the resulting damage can lead to total kidney failure.(Kumar V. 2013)

Diabetic nephropathy: High blood sugar from diabetes progressively damages the kidneys, eventually causing chronic kidney disease. Protein in the urine (nephrotic syndrome) may also result.(Kumar V. 2013)

Hypertensive nephropathy: Kidney damage caused by high blood pressure. Chronic renal failure may eventually result.(Kumar V. 2013)

Kidney cancer: Renal cell carcinoma is the most common cancer affecting the kidney. Smoking is the most common cause of kidney cancer.(Kumar V. 2013)

Interstitial nephritis: Inflammation of the connective tissue inside the kidney, often causing acute renal failure. Allergic reactions and drug side effects are the usual causes.(Kumar V. 2013)

Minimal change disease: A form of nephrotic syndrome in which kidney cells look almost normal under the microscope. The disease can cause significant leg swelling (edema). Steroids are used to treat minimal change disease.

Nephrogenic diabetes insipidus: The kidneys lose the ability to concentrate the urine, usually due to a drug reaction. Although it's rarely dangerous, diabetes insipidus causes constant thirst and frequent urination.(Kumar V. 2013)

Renal cyst: A benign hollowed-out space in the kidney. Isolated kidney cysts occur in many normal people and almost never impair kidney function.(Kumar V. 2013)

2.2Previous studies :

Kazuo (2003) described comparison of methods for determination of glomerular filtration rate: Tc-99m-DTPA renography, predicted creatinine clearance method and plasma sample method, the gamma camera uptake method with Tc-99m-DTPA is simple and less time consuming for the determination of the glomerular filtration rate (GFR). The data was collected using Tc-99m-DTPA renography which performed on 133 patients (69 males and 64 females; age range being 24 to 84 years) with a wide range of renal function. The GFR was determined simultaneously by 3 methods; (1) gamma camera uptake method (modified Gates, Gates); (2) predicted creatinine clearance method (Cockcroft-Gault, CG); (3) single- or two-plasma clearance method (plasma sample clearance method, PSC). The PSC was chosen as a reference. The result showed that the regression equation of the Gates and the CG against the PSC was $Y = 11.89 + 1.041X$ ($r = 0.790$, $p < 0.001$, RMSE = 23.55 ml/min/1.73 m2) and $Y = 8.845 + 0.7899X$ ($r = 0.8270$, $p < 0.001$, RMSE = 16.27 ml/min/1.73 m2), respectively. In comparison with the GFR by PSC, the Gates tended to overestimate the GFR, and contrarily

the CG tended to underestimate the GFR. In the conclusion the Gates correlates well with the PSC. However, the Gates is even less precise than the CG. The Gates' method in Tc-99m-DTPA renography is not suitable for the estimation of GFR in routine practice.

Fabio et al. (2002) described evaluation of renal function: A Comparison Between Camera-Based Tc-99mMAG3 and 24-Hour Creatinine Clearances. The Objective of their study was to evaluate the 24-hour creatinine clearance we hypothesized that a camera-based Tc-99m mercaptoacetyltriglycine (MAG3) clearance obtained simultaneously with a standard MAG3 scan would correlate well with the 24-hour creatinine clearance and could serve as a simple marker of renal function. The data were obtained from a retrospective analysis of 28 patients with varying degrees of renal dysfunction and 85 subjects evaluated for kidney donation. The MAG3 clearance was calculated using a camera-based technique without blood or urine sampling. The creatinine clearance was measured using the plasma creatinine and 24-hour urine collection. The MAG3 and creatinine clearances were corrected for body surface area and values in normal subjects and patients were compared using paired T-test analysis. The linear association between the MAG3 and creatinine clearances was expressed by Pearson's correlation coefficient. And results showed that the mean MAG3 clearance in the potential renal donors was 321 -95 ml/min (95% C.I. 171-546 ml/min), significantly higher than the mean creatinine clearance of 152 -51 ml/min (95% C.I. 79-278 ml/min, $p<0.001$). The mean MAG3 clearance in patients was 153 -70 ml/min (95% C.I. 32-316 ml/min) and was also significantly higher than the mean creatinine clearance of 74 -36 ml/min (95% C.I. 21- 138 ml/min, $p<0.001$). The ratio of the mean creatinine clearance to the mean MAG3 clearance was essentially the same for volunteers and patients, 0.47 and 0.48,1 respectively. The Pearson's correlation between the MAG3 and creatinine clearances was 0.80 (95% C.I. 0.72-0.86). In the conclusion the camera-based Tc-99m MAG3 clearance correlates well with the 24-hour creatinine clearance and can provide a simple and convenient index of renal function.

Amgad (2004) described serum cystatin c: a good marker for evaluation of glomerular filtration rate in hepatorenal syndrome, The aim of him study was to determine if estimation of serum cystatin C could replace creatinine clearance in routine determinations of glomerular filtration rate (GFR) for early detection of kidney affection in patients with cirrhosis in a case control study. The data was collected using 20 group C and 20 group B patients i.e. a total of

40 patients were included in the study. Twenty ages, sex and body mass index matched were used as controls. Serum creatinine and creatinine clearance were measured by Jaffe reaction. GFR was measured by 99mTc-DTPA technique. Serum cystatin C was measured by particle enhanced immunoturbidimetry. Pearson correlation analyses showed that cystatin C has no correlation with age or body mass index. Moreover, cystatin C showed more significant correlation(r:-0.85, $p<0.001$), than serum creatinine (r:-0.32, $p<0.05$) with GFR measured with 99mTc-DTPA technique in patients with cirrhosis. The results demonstrated that serum cystatin C values were significantly higher in hepatorenal syndrome patients than in controls. The results showed that neither serum creatinine nor creatinine clearance were good indicators of hepatorenal syndrome(r: 0.089). Serum cystatin C level is independent of age or body mass index. In the conclusion we suggest that serum cystatin C assay may be useful marker for early detection of renal insufficiency in hepatorenal syndrome. Also, the increase in cystatin C is higher in decompensates cirrhotic patients than in compensated cirrhotic patients.

Henrik et al. (2010) described estimating GFR in children with 99mTc-DTPA renography. The aim of their study was to evaluate the accuracy of this non-invasive method in children. The data was collected from calculated GFR from 99mTc-diethylene triaminepenta acetic acid (DTPA) renography and compared with 51Cr-EDTA plasma clearance of 29 children between the age of 1 month and 12 years (mean 4•7 years). The result showed that the correlation between 99mTc-DTPA renography and 51Cr-EDTA plasma clearance was for all children R = 0•96 (n = 29, P<0•0001), for children above 2 years of age R = 0•96 (n = 18, P<0•0001) and for children <2 years R = 0•84 (n = 11, P<0•001). In the conclusion we conclude that assessment of GFR from 99mTc-DTPA renography is reliable and comparable to GFR calculated from 51Cr-EDTA plasma clearance. Because our method is non-invasive and only takes 21 min, it may be preferable in many cases where an assessment of renal function is needed in children especially when renography is performed anyhow.

Nik et al. (2010) described sensitivity of serum creatinine in assessing renal function in type 2 diabetes mellitus with normal urinary protein excretion. The aim of their study was to determine the sensitivity of serum creatinine in assessing renal function in type 2 diabetes mellitus patients who have no proteinuria on routine urine dipstick testing. The data was

collected using Type 2 DM patients with normoalbuminuria confirmed on urine ACR were selected from endocrine clinic. All patients had their renal profile taken and subsequently the GFR measurements were performed using 99mTc-DTPA renal dynamic imaging. The result showed that a total of 93 subjects had their GFR measured by both the DTPA and MDRD methods. The mean GFR by DTPA method was 79.96 ± 29.53 mls/min/1.73m2 and the median by the MDRD methods was 82.00 (35.00) mls/min/1.73m2. Thirty two (34%) of the subjects were in Stage 1, 37 (39%) were in CKD Stage 2, 22 (23%) were in stage 3 and 2 subjects (0.02%) were in CKD stage 4. Among them 37 (39%) subjects had a normal creatinine level despite the renal impairment (false negative results).The use of serum creatinine to estimate renal function in a patient with GFR. In the conclusion he sensitivity of serum creatinine as an index of renal function dropped to 60% when the GFR dropped to below 60 mls/min/1.73m2. It is wise not to rely on serum creatinine when CKD is suspected in DM patients.

Yufeng et al. (2007) described the relationship between the renal apparent diffusion coefficient (ADC) and glomerular filtration rate. The Purpose of their study was to investigate the relationship between ADC values measured by diffusion-weighted MRI (DWI) and the split glomerular filtration rate (GFR). The data was collected by using DWI (b = 0 and 500 seconds/mm2), which was performed with a 1.5T MR unit in 55 patients. The ADCs were calculated with ROIs positioned in the renal parenchyma, and the split GFRs were measured by 99 mTc DTPA scintigraphy using Gates' method. The 110 kidneys were divided into four groups: normal renal function (GFR 40 mL\minute), mild renal impairment (40 > GFR ≥ 20 mL\minute), moderate renal impairment (20 > GFR ≥ 10 mL\minute), and severe renal impairment (GFR < 10 mL\minute). The renal ADCs between the four groups were statistically compared by using analysis of variance (ANOVA) and the relationship between ADCs and GFR was examined by using Pearson's correlation test; the results showed that the mean renal ADCs of the four groups were 2.87±0.11, 2.55±0.17, 2.29±0.10, and 2.20± 0.11 × 10−3mm2\second, respectively. There was a statistically significant difference in renal ADCs among the four groups ($p < 0.001$). There was a positive correlation between the ADCs and split GFR ($r = 0.709$). In conclusion; the ADCs were significantly lower in impaired kidneys than in normal kidneys, and there was a positive correlation between the ADCs and GFR.

Jagdish et al. (1987) described evaluation of renal function in diabetics employing two different methods, the objectives of their study was to evaluate renal function by endogenous creatinine clearance and compare this with GFR, employing gamma camera using technetium diethylenetriaminepenta acetate (TC DTPA), to correlate type of diabetes, duration, glycemic control, blood pressure and large vessel disease, serum creatinine and lipids with severity of renal decomposition and to conduct follow up studies on renal function to assess the rate of progression of diabetic renal disease. The data was collected using 27 cases of diabetes mellitus were selected, going by the criteria of 24 hour urinary albumin excretion >250 mg/24 hours from the Endocrinology wards and out-patient of Endocrinology Unit at All India Institute of Medical Sciences, New Delhi. There were 18 males and 9 females. 13 patients were IDDM type while 14 were NIDDM type. Mean ages in IDDM - 27.1 years and NIDDM 58.5 yrs. while mean duration of DM was IDDM-7.1 yrs and NIDDM-11.1 yrs. Endogenous creatinine clearance measured by accurately timed collection of 24 hour urine, twice and mean of two values taken. Glycosylated hemoglobin estimation was done by colorimetric method. GFR Tc DTPA using gamma camera and radioisotope method was based on plasma clearance of injected TC 99m DTPA, determined by serial collection of blood samples. The result showed that Routine investigation in two groups, IDDM and NIDDM revealed mean values of Hb A1C of 12.23% and 11.66% (Table I) respectively, reflecting poor control at the time of inclusion in the study. Lipid profile also revealed raised values in both the groups (Table I). Glomerular filtration rate in the groups was studied and classified into 3 groups as : Group I with GFR > 100 ml/mt, Group II with GFR 50-100 ml/mt, Group III with GFR <50 ml/mt. Total number of cases studied in these groups was 8, l0 and 9 respectively (Table II). A direct correlation between 24 hour urinary albumin, serum creatinine and glomerular filtration was observed (Table III). In the conclusion the present study it was observed that endogenous creatinine clearance if done meticulously gives a fairly accurate measure of GFR. Gamma camera method though more accurate and sensitive is slightly more expensive. In follow up studies up to 1½ years in 5 cases with advanced renal involvement there was rapid decline in GFR (30 ml/year) which is probably 2-3 times as compared to earlier data from West. It was further observed that IDDM group was free of large vessel disease in this sample group of 27 cases. Incidence of small vessel disease is independent of LVD and this may be dependent on racial factors. It is concluded that in assessment of diabetic renal disease advancement, critical criteria for defining advanced renal involvement be S. creatinine>2.5

ml/dl and GFR <50 ml/mt beyond which a nephrologists should intervene and offer a life plan to a diabetic.

Jose et al. (2010) described Comparison of four methods for measuring glomerular filtration rate by inulin clearance in healthy individuals and patients with renal failure. The aim of their study was to compare the performances of 4 glomerular filtration rate tests with inulin clearance in patients with chronic renal insufficiency and in healthy subjects. The data was collected using 51 individuals with stable renal function were selected. For each of them, we computed 4 estimates: the 24-hour creatinine clearance, technetium (99mTc-DTPA) clearance, and Cockcroft-Gault and Levey formulas. Their respective performance was assessed by correlation (Pearson's correlation coefficient) and agreement (Bland and Altman method). And the result showed that the each glomerular filtration rate test closely correlated with inulin clearance. Nevertheless, all GFR tests displayed considerable lack of agreement with lower limits ranging from 15 to 42 ml / min, for comparison with inulin-technetium and inulin with Levey formula, respectively and upper limits of agreement that could range from 20 to 56 ml / min, for comparison with inulin-technetium and Inulin with Levey formula, respectively. In the conclusion the measurement of glomerular filtration rate determined via different methods shows a wide range of variation when compared with inulin clearance, which should be considered in daily clinical practice during the evaluation of renal function.

Barbara et al, (2011) described comparison of 99m Tc DTPA vs. five methods to estimate glomerular filtration rate in children with renal transplantation. The purpose of their study was to compare the GFR obtained with 99mTc DTPA against five other methods. The data was collected using Patients with renal transplant and stable renal function (defined as those in whom the serum creatinine levels had not changed by more than 0.2 mg per deciliter during the previous three months) were invited to participate in the study. Those patients with graft dysfunction or known recurrence of the original disease were excluded. The study was approved by the IRB and parental and children informed consent/assent was obtained in all cases. The gold standard used for estimate GFR was 99m Tc-DTPA, since it has a clearance similar to insulin. Dynamic images were obtained in supine position after an intravenous administration of 99m Tc-DTPA dose, using a gamma camera during 30 minutes and then processed to generate the time-activity curves that allow analyzing the perfusion and

filtration. The result showed that the mean GFR obtained with 99m Tc-DTPA was 66.9 mL/min 15, whereas by Ccr was 68.7 24.4, by Schwartz formula 81.8 15.9, by the Counahan-Barrat equation was 57.6 13.6, by Morris equation 60.7 14.5 and by Leger equation 73.2 18.3. GFR by all methods was normally distributed by D'Agostino& Pearson omnibus normality test. There was a significant correlation between GFR by 99mTc-DTPA vs. Ccr (Pearson r = 0.316, p= 0.040), 99mTc-DTPA vs. Schwartz (Pearson r = 0.500, p=0.0007), 99mTc-DTPA vs. Counahan-Barrat formula (r= 0.492, p=0.0009), 99mTc-DTPA vs. Morris (r= 0.492, p=0.0009) and 99mTc-DTPA vs. Leger (r= 0.494, p= 0.0009). In the conclusion, in our study Ccr showed the lowest bias and the higher precision to estimate GFR in renal transplant children. This method is inconvenient as it is cumbersome to patients and their families, and patients without bladder control will require bladder catheterization.

Gang et al. (2005) described GFR determined in conjunction with 99m Tc-DTPA; the aim of their study was to assess the GFR requires numerous blood samples obtained over period of several hours to determine plasma concentration of injected radiopharmaceutical. The data was collected using less than 40 min of imaging time and single blood sampling. The 99m-Tc-DTPA clearances was measered with Jackonmothed during the rotune 99m-Tc-DTPA in 63 patient ,in the 23 cases among 63 creatinine clearances was accounted simultaneously. The result showed that the range of clearances DTPA from 19.9 ml\min to 170ml\min and the correlation of clearances DTPA and creatinine clearances was described by Y 16.2570+0.7852X(X=Cl DTPA,Y=Clceratinine) and the correlation coefficient r was 0.88. In the conclusion 99m-Tc-DTPA renal clearances measurment with Jackonmothedclinicalyusefull to account GFR that can be done with 99m-Tc-DTPA renal scintigraphy simultaneously.

Julie et al. (2003) described comparison of prediction equations for estimating glomerular filtration rate in adults without kidney disease, the aim of their study was to evaluated the ability of the Modification of Renal Disease (MDRD) equation to predict GFR when

compared with multiple other prediction equations in healthy subjects without known kidney disease was analyzed. The data was collected using 117 healthy individuals underwent 125I-iothalamate or 99mTc-diethylenetriamine-pentaacetic acid (DTPA) renal studies as part of a routine kidney donor evaluation at either Brigham and Women's Hospital or Boston Children's Hospital. On chart review, 100 individuals had sufficient data for analysis. The MDRD 1, MDRD 2 (simplified MDRD equation), Cockcroft-Gault (CG), Cockcroft-Gault corrected for GFR (CG-GFR), and other equations were tested. The result showed that The median absolute difference in ml/min per 1.73 m2 between calculated and measured GFR was 28.7 for MDRD 1, 18.5 for MDRD 2, 33.1 for CG, and 28.6 for CG-GFR in the 125I-iothalamate group and was 31.1 for MDRD 1, 38.2 for MDRD 2, 22.0 for CG, and 31.1 for CG-GFR in the 99mTc-DTPA group. Bias was -0.5, -3.3, 25.6, and 5.0 for MDRD 1, MDRD 2, CG, and CG-GFR, respectively, in subjects who received 125I-iothalamate and -33.2, -36.5, 6.0, and -15.0 for MDRD 1, MDRD 2, CG, and CG-GFR, respectively, in those who received 99mTc-DTPA studies. Precision testing, as measured by linear regression, yielded R2 values of 0.04 for CG, 0.05 for CG-GFR, 0.15 for MDRD 1, and 0.14 for MDRD in those who underwent 125I-iothalamate studies and 0.18 for CG, 0.21 for CG-GFR, 0.40 for MDRD 1, and 0.38 for MDRD 2 for those who underwent 99mTc-DTPA studies. The MDRD equations were more accurate within 30 and 50% of the measured GFR compared with the CG and CG-GFR equations. When compared with the CG equation, the MDRD equations are more precise and more accurate for predicting GFR in healthy adults. In the conclusion The MDRD equations, however, consistently underestimate GFR, whereas the CG equations consistently overestimate measured GFR in people with normal renal function. In potential kidney donors, prediction equations may not be sufficient for estimating GFR; radioisotope studies may be needed for a better assessment of GFR.

James et al. (1992) described Serum Creatinine Level and Renal Function in Children, the aim of their study was to evaluate the accuracy of serum creatinine and height/serum creatinine glomerular filtration rate (CrGFR) formula as screening tests for abnormal renal function defined by plasma diethylenetriaminepenta-acetic acid (DTPA) clearance. The data was collected using Eighty-seven consecutive patients ranging in age from 2 to 20 years. The Cr-GFR was calculated by means of the formula GFR (milliliters per minute per 1.73 m2) =kl/serum creatinine (milligrams per deciliter), where L is body length in centimeters and k is

a constant dependent on age and sex. Plasma clearance of technetium Tc 99m-labeled DTPA was our reference method for determination of GFR (DTPA-GFR). The result showed that The Cr-GFR formula identified children with impaired renal function (DTPA clearance, <80 mL/min per 1.73 m2) with a sensitivity of 95% and a specificity of 93%. In contrast, the sensitivity and specificity of elevated serum creatinine level for this purpose were 80% and 96%, respectively. Of the children with renal insufficiency (DTPA clearance, 40 to 79 mL/min per 1.73 m2), 91% were correctly identified by the Cr-GFR formula. However, only 65% of these children had elevated serum creatinine levels. Although all children with renal failure (DTPA clearance, <40 mL/min per 1.73 m2) had abnormally high serum creatinine levels, the specificity of this test was significantly lower than that of the Cr-GFR formula (75% vs. 100%, respectively). In the conclusion The Cr-GFR formula is superior to serum creatinine level for estimating GFR. This formula provides a simple, reasonably accurate screening test for the presence and severity of impaired renal function.

Kazuo et al. (2002) described Accuracy of plasma sample methods for determination of glomerular filtration rate with 99mTc-DTPA. The aim of their study was to assess clinical accuracy of single-, two- and multi-sample methods. The data was collected using 50 patients with various degrees of renal dysfunction (29 males and 21 females; aged 27 to 90 years). As a reference the true GFR (GFRt) was determined by means of the two-compartment model curve fitting 10 plasma samples following a single injection of 99mTc-DTPA. The GFRt was compared to the GFR estimated by the Christensen and Groth's single-sample (GFRcg), two-sample (GFR2s) and multi-sample (GFRm) between 75 and 300 min after the injection. The GFRs by two- and multi-sample methods were determined with the slope and intercept algorithm and its overestimation were corrected by Brochner-Mortensen's formula. The result showed that In 49 patients with GFR between 12 and 169 ml/min/1.73 m2, the standard deviation of difference (95% limits of agreement) between GFRt and GFRcg at 180 min was 6.513 ml/min/173 m2 (−16.5 ~ 9.5 ml/min/1.73 m2), which was somewhat closer than 7.311 ml/min/1.73 m2 (−12.5 ~ 16.5 ml/min/1.73 m2) in GFR2s in slow clearance phase at 120 min and 240 min. However, the single-sample method tended to show some scattering in GFR below 30 and above 140 ml/min/1.73 m2. On the contrary, the 2-sample method tended to be scattered in GFR above 120 ml/min/ 1.73 m2. In the conclusion In view of its accuracy and technical simplicity, the single-sample method is first choice in a routine practice. The two-

sample method is essential of choice for a patient in whom the GFR is expected to be below 30 ml/min/1.73 m2. These two methods may be chosen selectively in dependence on the preserved renal function which is expected at time of the test.

Dong et al. (2004) described comparison of various methods for estimating glomerular filtration rate in patients with chronic kidney diseases. The aim of their study was to investigate the variation in GFR measured by different methods and to determine the most accurate method in estimating GFR. The data was collected using total of 549 patients with stage 2-5 chronic kidney disease (CKD) who underwent 24-hour urine study and 99mTc-DTPA renal scan were enrolled. GFR was also calculated by using Cockcroft-Gault (CG-GFR) and MDRD equation (MDRD-GFR). The correlations between GFR estimated by MDRD and other methods were analyzed according to the age of patient (<40, 40-59, and 60 years) ≥ and the stage of CKD. The result showed that the mean age of patients was 55±19 year with sex ratio 1.5:1 and the mean MDRD-GFR was 22.5± 18.7mL/min/1.73m2. Estimated GFR by 99mTc-DTPA renal scan and CG-GFR, and creatinine clearance by 24-hour urine study (Ccr-GFR) correlated significantly with MDRD-GFR in all age groups and in all CKD stages ($p < 0.01$). However, the ratios of CG-GFR/MDRD-GFR and Ccr/MDRD-GFR were 1.29±0.20 and 1.05±0.43, respectively, whereas DTPA-GFR/MDRD-GFR ratio was 2.24±1.40 in patients with stage 5 CKD, suggesting that DTPA renal scan overestimates GFR in advanced renal failure patients. Similar patterns (Ratios of CG-GFR, Ccr-GFR, and DTPA-GFR to MDRD-GFR; 1.00±0.17, 0.94±0.33, and 1.62±1.12, respectively) were also observed in old-aged patients. In the conclusion Even though Ccr, DPTA-GFR, and CG-GFR correlated significantly with MDRD-GFR, DTPA renal scan tends to overestimate GFR, especially in old-aged and advanced CKD patients.

Anna et al. (2008) described effect of creatinine methods on the eGFR; the aim of their study was to evaluate the effect of creatinine on the eGFR. The data was collected using Original 6-v MDRD (Modification of Diet in Renal Disease), 4-v MDRD, Cockcroft-Gault (C-G), Quadratic and the new MDRD-175 formulae were tested in 31 patients. The eGFR based on both Jaffe and compensated-Jaffe creatinine was compared to Tc-99m labeled diethylenetriaminepentaacetic acid clearance (DTPA-GFR). The result showed that all eGFRs correlated with DTPA-GFR (range 16–104 mL/min/1.73 m 2). Original MDRD and C-G

showed high correlation coefficients (0.88 and 0.78), but original and 4-v MDRD tended to overestimate GFR below 60 ml/min/1.73 m 2 and underestimate it above 60 mL/min/1.73 m 2. Using compensated-Jaffe creatinine reduced the underestimation of the original MDRD, but resulted in overestimation of the 4-v MDRD, C-G and quadratic GFR. With the exception of the original MDRD, the correlations between eGFRs and DTPA-GFR were higher using Jaffe method. Applying the new MDRD-175 with compensated Jaffe creatinine resulted in lower bias of GFR. In the conclusion Harmonization of creatinine methods is necessary because it has significant effect on the eGFR. The IDMS-calibrated creatinine in the new MDRD-175 formula provides reliable eGFR in kidney disease.

Julie et al. (2003) described comparison of prediction equations for estimating glomerular filtration rate in adults without kidney disease, the aim of their study was to evaluated the ability of the Modification of Renal Disease (MDRD) equation to predict GFR when compared with multiple other prediction equations in healthy subjects without known kidney disease was analyzed. The data was collected using 117 healthy individuals underwent 125I-iothalamate or 99mTc-diethylenetriamine-pentaacetic acid (DTPA) renal studies as part of a routine kidney donor evaluation at either Brigham and Women's Hospital or Boston Children's Hospital. On chart review, 100 individuals had sufficient data for analysis. The MDRD 1, MDRD 2 (simplified MDRD equation), Cockcroft-Gault (CG), Cockcroft-Gault corrected for GFR (CG-GFR), and other equations were tested. The result showed that The median absolute difference in ml/min per 1.73 m2 between calculated and measured GFR was 28.7 for MDRD 1, 18.5 for MDRD 2, 33.1 for CG, and 28.6 for CG-GFR in the 125I-iothalamate group and was 31.1 for MDRD 1, 38.2 for MDRD 2, 22.0 for CG, and 31.1 for CG-GFR in the 99mTc-DTPA group. Bias was -0.5, -3.3, 25.6, and 5.0 for MDRD 1, MDRD 2, CG, and CG-GFR, respectively, in subjects who received 125I-iothalamate and -33.2, -36.5, 6.0, and -15.0 for MDRD 1, MDRD 2, CG, and CG-GFR, respectively, in those who received 99mTc-DTPA studies. Precision testing, as measured by linear regression, yielded R2 values of 0.04 for CG, 0.05 for CG-GFR, 0.15 for MDRD 1, and 0.14 for MDRD in those who underwent 125I-iothalamate studies and 0.18 for CG, 0.21 for CG-GFR, 0.40 for MDRD 1, and 0.38 for MDRD 2 for those who underwent 99mTc-DTPA studies. The MDRD equations were more accurate within 30 and 50% of the measured GFR compared with the CG and CG-GFR equations. When compared with the CG equation, the MDRD equations are

more precise and more accurate for predicting GFR in healthy adults. In the conclusion The MDRD equations, however, consistently underestimate GFR, whereas the CG equations consistently overestimate measured GFR in people with normal renal function. In potential kidney donors, prediction equations may not be sufficient for estimating GFR; radioisotope studies may be needed for a better assessment of GFR.

Chapter Three
Material and Method

In this chapter describe the material used to collect the data and method of the study which include study area, study variable, study design, study sampling, method of data collection and method of data analysis.

3.1 Materials:

In this study adose calibrator was used to measure the activity of radiopharmaceutical before administration to the patient, as well the data acquired form the region of interest using SPECT gamma camera in the renal scintigraphy**,** .

3.1.1 Dose calibrator (Isomed 1000):

was used the dose calibrator model **Isomed 1000** manufactured in austria, with specification of :

Activity range: 40 KBq - 200 GBq .

Resolution: 0.001 MBq .

Energy range: 25Kev – 3Mev .

Response time: 1 to 3 seconds .

Detector: pressurized fill with argon.

Voltage: 150 V.

Principle of operation: The typical radioisotope calibrator contains an ionization chamber, a high voltage power supply, an electronic amplifier, and a display unit on which one can select the radioisotope to be calibrated. The ionization chamber is cylindrical in shape and is used to measure the total amount of ionization produced by the sample to be calibrated. The ionization chamber contains Argon gas under high pressure, and the hermetically sealed chamber contains two electrodes having an electric potential between them. When the vial or syringe containing the radionuclide is placed into the chamber, the Argon gas is ionized, the ion pairs migrate toward the anode and cathode and an electrical current flows between them.

This current is proportional to the activity of the measured radioisotope. The magnitude of this current is usually very small (on the microampere level), even if large amounts of activity are present. A device called an electrometer, designed for quantifying very small electric currents, is used and its output is displayed in either mCi or MBq. Dose calibrator function is based on a number of parameters.

3.1.2 Gamma camera (SPECT "Multicam 2000") :

Was used SPECT multicam 2000 medical imaging systems with dual head and camera large field of view and collimator low energy general purpose .

SPECT is short for Single Photon Emission Computed Tomography,is a nuclear medicine tomographic imaging technique using gamma rays. It is very similar to conventional nuclear medicine planar imaging using a gamma camera. However, it is able to provide true 3D information. This information is typically presented as cross-sectional slices through the patient, but can be freely reformatted or manipulated as required.

Instead of just "taking a picture" of anatomical structures, a SPECT scan monitors level of biological activity at each place in the 3-D region analyzed. Emissions from the radionuclide indicate amounts of blood flow in the capillaries of the imaged regions. In the same way that a plain X-ray is a 2-dimensional (2-D) view of a 3-dimensional structure, the image obtained by a gamma camera is a 2-D view of 3-D distribution of a radionuclide.

SPECT imaging is performed by using a gamma camera to acquire multiple 2-D images (also called projections), from multiple angles. A computer is then used to apply a tomographic reconstruction algorithm to the multiple projections, yielding a 3-D data set. This data set may then be manipulated to show thin slices along any chosen axis of the body, similar to those obtained from other tomographic techniques, such as magnetic resonance imaging (MRI), X-ray computed tomography (X-ray CT), and positron emission tomography (PET).

3.1.3Study design:

Analytical study where the result of the GFR in TC^{99m} DTPA renogram will be assessed using creatinine clearance test as a reference.

3.1.4Sample size of the study:

The sample size of this study included 50 patients with normal result of GFR (34male, 16 female)age range being from 18 to 70 years .

3.2Methods:

The data of this study was collected from Fedail hospital at the nuclear medicine departmentand medical laboratory in period from July 2016 to November 2016.

3.2.1 Method of data collection :

3.2.1.1Renal scintigraphy with GFR :

- Radiopharmaceutical : 99mTc-DTPA(diethylenetriaminepentaacetic acid).
- Dose : 5 mci .
- Method of Administration :intravenously in one bolus , use butterfly for a diuretic (furosemide 20 mg) .
- Patient Preparation :Instruct patient to hydrate well (water; up to 10 mL/kg) and void just before test , the hydration should continue between studies.
- Procedure :
    - Before start the scan should be measure the count of syringe before and after injection to calculate the GFR.
    - Place the patient in supine position and the camera posterior to the patient, in the pelvic kidney we use two detectors one anterior and one posterior to the patient.
    - Position camera by point source over xiphoid, umbilicus, pubic symphysis, and sides in field of view.
    - Inject 5mCi 99mTc-DTPA intravenously in one bolus and start the study.

3.2.1.2Creatinine clearance test :

Creatinine clearance is calculated from the Cockcroft-Gault formula, which estimates GFR in mL/min: It is named after the scientists who first published the formula, and it employs serum creatinine measurements and a patient's weight to predict the creatinine clearance. The formula, as originally published, is:

$$\mathrm{eCcr} = \frac{(140 - \mathrm{Age}) \times \mathrm{Mass(in\ kilograms)} \times [0.85\ \mathrm{if\ female}]}{72 \times \mathrm{Serum\ Creatinine(in\ mg/dL)}}$$

3.2.2. Study variable:

The data of this study was collected from patient age, weight and height, gender, total GFR renal scan (ml/min)andcreatinine clearance result (ml/min) .

3.2.3. Method of Data analysis:

The result of this study analyzed using ExcelandSPSS (statistical package for social studies), The result will be shown in a form of correlation between renal scintigraphy with GFR and creatinineclearance .

Chapter Four

Results

Table 4-1 the mean ± standard deviation of body characteristics and renal function

Variable	Mean ± SD
Age	48.4±13.9
BMI	22.8±3.8
Total GFR	96.1±21.4
Creatinine clearance	85.1±19.7

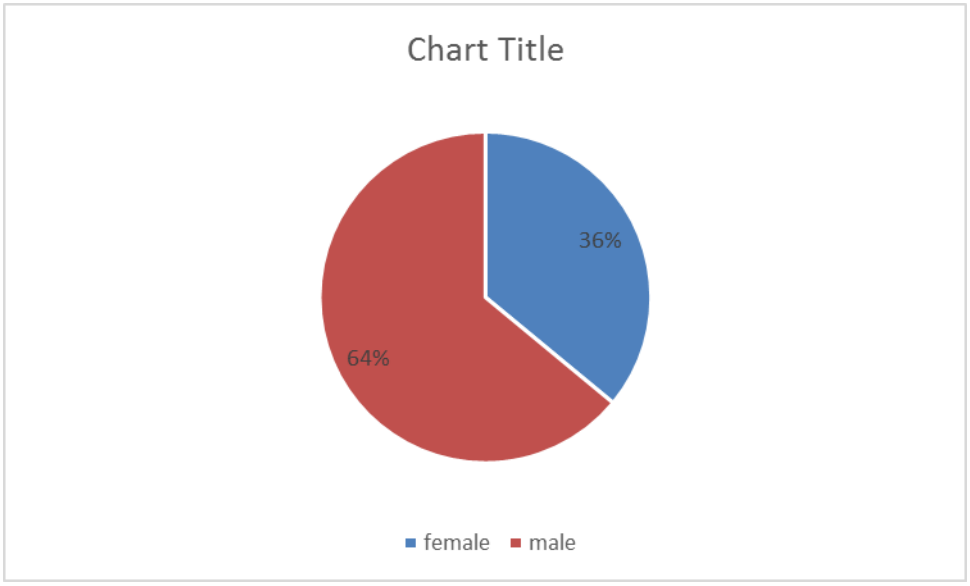

Figure 4:1 a pie graph shows gender percentage distribution

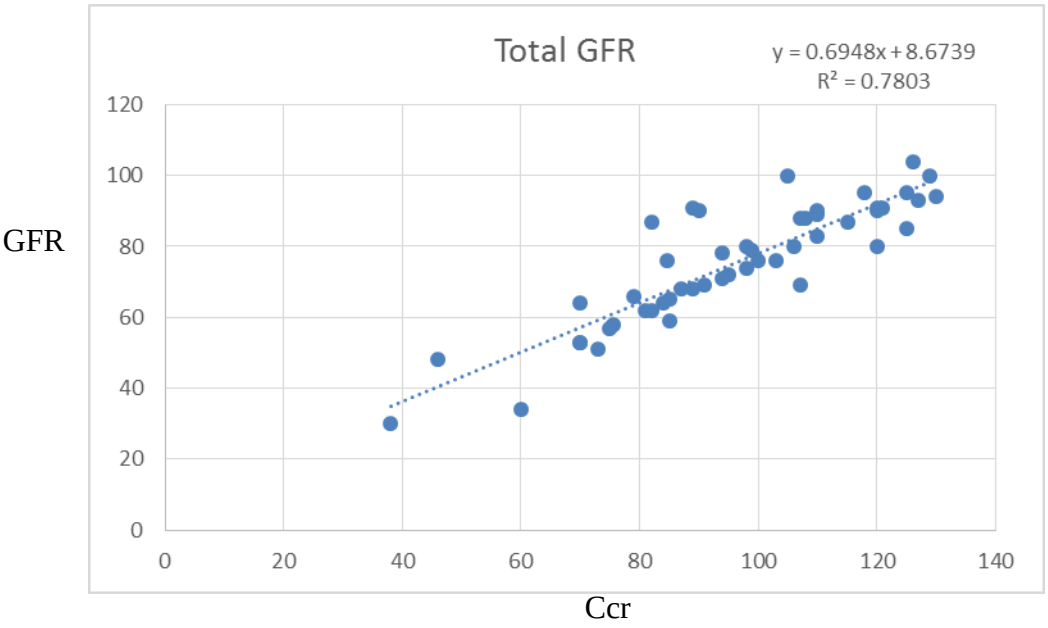

Figure 4:2 a scatter plot show direct linear relationship between creatinine clearance and GFR result using renal scintigraphy

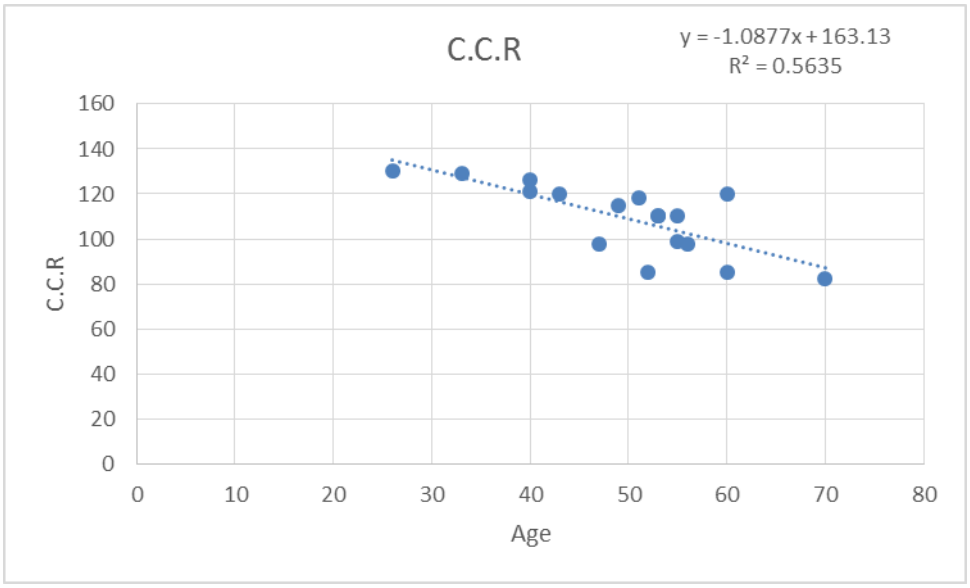

Figure 4:3 a scatter plot show an inverse linear relationship between creatinine clearance and patient age.

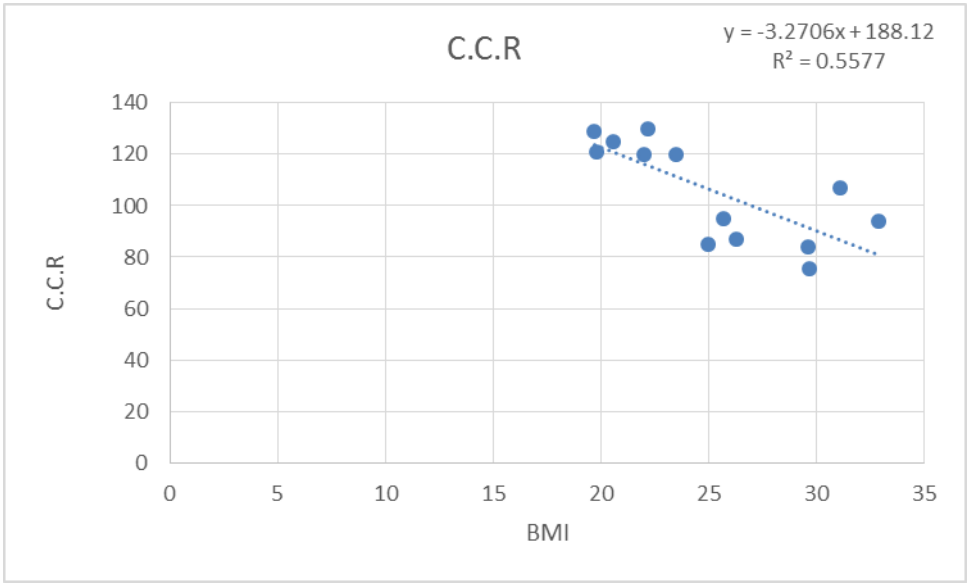

Figure 4:4 a scatter plot show an inverse linear relationship between creatinine clearance and BMI

Chapter Five

Discussion, Conclusion and Recommendation

5.1 Discussion

The sample of this study included 50 patients with result of GFR using renal scintigraphy and creatinineclearance, the main objective was to evaluate renal function using renal scintigraphy and creatinine clearance.

Since GFR can be measured using renal scintigraphy or creatinine clearance; the result of this study revealed that, there is a direct relationship between GFR result of renal scintigraphy and creatinine clearance .The two methods correlated well together, with a correlation coefficient of 0.88 and hence the values of GRF result using renal scintigraphyare reliable with an accuracy of ٨٨.5% (Figure 4-2) such result are in agreement with Fabio et al. (2002) and Gang et al. (2005).

Age and body mass index (BMI) also influenced the result ofcreatinine clearance. In case of age, creatinine clearance decreased linearly when age increases i.e. an inverse linear relationship for both methods. Such result has been mentioned by Kim HO et al. (2010).

Concerning BMI also it has an inverse linear relationship with the value of creatinine clearance using renal scintigraphy.

5-2 Conclusion

This study was carried out in order to evaluate renal function using renal scintigraphy with the creatinine clearance used as a reference

The data of this study collected from 50 patients their renal function was assessed using renal scintigraphy and creatinine clearance in Fedail Hospital(the N.M. departmentand medical laboratory), where the data were collected prospectively.

The results of this study showed that there is a direct linear relationship between renal scintigraphy and creatinine clearance, with a strong correlation between them. The age of patient correlated inversely withcreatinine clearance results. Similarly the body mass index and thecreatinine clearance results showed inverse linear association.`

In summary the results of GFR determined by renal scintigraphy are reliable and accurate.

5.3 Recommendation

- Renalscintigraphy should be the investigation of the choice in all the renal problems as it gives an accurate GFR beside other results that shows all the parameters of the renal function (spilt function ,perfusion and time activity curve).
- Large sample can be incorporated to study the relation between renal diseases and gender.
- Physicians should put in concern age and body mass of the patient when determining normal renal function.

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