Chapter one

1-1 Introduction:
Renal transplantation has grown rapidly over the past 30 years, resulting in an inadequate supply of organs to meet the ever-increasing demand. This has led to an increase in the number of living-related donors. (Rankin, 2001)

Renal transplantation leads to better survival and quality including detailed medical history, laboratory testing and of life for patients with renal failure. It has become the treatment of choice for the end stage renal disease. (Kaynan 1999).

Renal transplantation represents the best available replacement treatment for patients with end stage renal disease patients than performing dialysis, and living Donor renal transplantation has been shown to offer better graft survival than cadaver donor renal transplantation. However, adequate preoperative living kidney donor evaluation is mandatory to reduce the possible occurrence of surgical complications that can threaten the graft, and sometimes the survival of the recipient. (Letourneau, 1998).

It was demonstrated that kidneys from living, unrelated donors succeed as well as kidneys obtained from brothers and sisters who share half of the tissue matching antigens (HLA antigens) with the kidney recipient. Thus, the pool of potential renal donors has expanded from first-degree relatives to include distant relatives, spouses, and close friends. The success rate of living donor kidney transplants, whatever the donor-recipient relationship, is significantly greater than that for cadaver kidneys.
Overall patient survival is also superior with living donor transplantation. It is also of utmost significance to minimize the risk to the potential living kidney donor. In addition, accurate delineation of renal anatomy to assist in surgical planning is a prerequisite for a successful transplant operation. Preoperative radiological evaluation of kidney donors is used to select the patient and the kidney that is to be harvested. Traditionally, renal angiography and excretory urography have been used to evaluate potential kidney donors. (Pozniak, and Cochran, 1998).

However, several studies have shown that spiral computed tomography (CT) angiography replace excretory urography and renal angiography in the evaluation of potential kidneys donors and has become an accepted modalities to evaluate renal arteries pre operatively (Alfrey, Cochetune, 2001).

The role of CTA in vascular evaluation of the renal transplant patient and evaluation of living donor is also addressed. by multi-slice spiral CT large volume can be scanned without decreasing signal to noise ratio, acquisition time are shorter due to higher pitch allowing for separation of arterial and venous phase. Thin and thick slice can be reconstructed, with fewer artifacts in 3D rendering and tube heating is deceased. Multidetectors CT is useful imaging modality that is replaced conventional angiogram in assessment of vascular anatomy and diagnosis of the vascular disorder. Recent development of hardware permits MDCT scanner (volume zoom) to provide high resolution data acquired in significant short time. The improvement of software for 3D
reconstruction, allows easy image manipulation on workstations of personal computer. (Joshi: AR 2004)

1-2 Problem of the study:
The renal arteries can be affected by a variety of diseases e.g. double renal artery, unilateral or bilateral, AVM, renovascular hypertension, congenital anomalies, renal artery stenosis, renal artery aneurysm. The problem of the study many donors come to donation for renal transplantation without clinical symptoms of renal disease. The need to confirm the true evaluation and diagnosis of the renal arteries for the donor by using MDCTA.

1-3 Objectives:
1-3-1 General Objective:
The main objective of this study to evaluate the role of multidetector CTA in diagnosis of renal vascular variations of the renal system in donors.

1-3-2 Specific Objective:
- To determine correlation age and gender and size of the renal arteries, to decide if the donor is normal and proved to donation or exclude.
- To evaluate efficiency and accuracy of spiral CT in demonstration of renal vascular anatomy with emphasis on the detection of arterial and venous anomalies.
- To find out the common configuration of renal artery to study if there any complications and limitation of spiral CT.

1-4 Significant
The multi-detectors CTA would be the imaging technique of the choice in the future once it solved many problems that founded in other modalities. The study will reveal and hopefully the efficiency of multi-detector CTA in diagnosis of renal arteries in donors.

1-5 Over view of the study
This study consist of five chapters, chapter one an include introduction; briefly, problem of study, general, specific objectives and significant of the study). Chapter two is contain (anatomy, physiology, pathology also & literature review about role of CT images in diagnosis of CTA renal angio.and previous studies) . Chapter three describe the methodology (material, method) that used in this study. Chapter four an include the result of presentation of final finding of study;. Chapter five included discussion, conclusion and recommendation for future scope in addition to references and appendices.
Chapter Two
Literature Review

2-1 Anatomy of the kidney and vascular:
The kidneys are the main part of urinary system, are made up of millions of nephrons that act as individual filtering unit and it complex structures themselves. The ureters, urethra and urinary bladder complete the urinary system.

In the human body the kidneys are located in abdominal cavity, more specifically in the paravertebral gutter and it lie in retroperitoneal position at slightly oblige position. Its two kidneys, one of each side of the spine. The symmetry within the abdominal cavity caused by liver typically results in the right kidney being slightly lower than the left, and the left kidney being located more medial than the right. A left kidney approximately at the vertebral level T12 to L3, and the right slightly lower. The site
of the right kidney just below the diaphragm and posterior to the liver, and the left below the diaphragm and posterior to the spleen. Right. (Ciffsnotes.com /study guide/Anatomy of the kidney)

Resting on top of each kidney is an adrenal gland which surrounded by tow layer ( therenal and pararenal fat ) and the renal fascia .In adult each kidney weight between 125 and 170 gram in males and between 115 and 155 gram in females. The left kidney is typically larger than the right. (Ciffsnotes.com /study guide/Anatomy of the kidney)

Figure 2-1: position of the kidney and its related organs .(Radiographic.rsna.org .2009)
2-1-1 Nerve supply
Autonomic nerves from the renal plexus follow the renal artery into the kidney through the renal hilum. The nerve fibers follow the branching pattern of renal artery and serve as vasomotor fibers that regulate blood volume. Sympathetic fibers constrict arterioles (decreasing urine output); while lessmemories parasympathetic fibers dilate arterioles (increase urine output) (. Barry &. Brenner 1991).

2-1-2 Renal vascular anatomy
The kidney are plentifully supplied with blood. it receive approximately one of fifth of the cardiac output, in the majority of
the human body, each kidney is supplied by a single renal artery and single renal vein. This one artery arising from the abdominal aorta, but in 25% of individuals, more than one artery can be presented. The renal arteries are usually 4 – 6 cm in length and 5 – 6 cm in width which arising from abdominal aorta and the inferior vena cava, respectively. These vessels originate of the aorta at the level of L2 below the takeoff of the superior mesenteric artery, with the vein anterior the artery. The right renal artery is one major vessel that pass posterior to inferior vena cava (IVC). Then the both vessels course anterior to the renal pelvic before entering the renal hilum. (Barry and Brenner 1991).

The right renal artery is typically a long download to inferior right kidney, conversely, and the left artery, which arises below the right renal artery and it more horizontal direction, has a rather direct upward more superiorly positioned to left kidney. In additions, the both renal arteries course in slightly posterior direction due to the position of the kidney. The main renal artery divides in into five segmental arteries near to the renal hilum. (SaggarMD 2003).

The first division is typically arises just prior to the renal hilum and passes posterior to the renal pelvic and supply the large portion of blood flow to the posterior portion of the kidney. Then the main renal artery continues before dividing into four anterior branches at the renal hilum: the apical, upper, middle, lower anterior segmental arteries. The apical and inferior arteries supply
the anterior and posterior surface of the upper and lower poles, and the upper and middle arteries supply the remainder of anterior surface. Then the segmental arteries course through the renal sinus and branch into lobar arteries. (Barry and Brenner 1991).

Farther divisions include the inter lobe arteries, arcuate. Relatively a vascular plane between the anterior and posterior arteries divisions of the kidney is an importance to the surgeon, because it allows for a clean incision toward the renal pelvic at the same time of surgery. This is located one third of the distance between the posterior and anterior surface of the kidney. (Barry and Brenner 1991)

The renal cortex is drained by the lobar, arcuate and interlobar veins. The lobar veins joint to form the main renal vein, which usually lies anterior to the renal artery at the renal hilum. The LT renal vein is longer than the RT renal vein, has averages 6 to 10 cm in length and well normally course anteriorly between the SMA and the aorta before emptying into the medial aspect of IVC. The RT renal artery average 2 to 4 cm in length and joint the lateral aspect of the IVC unlike the RT renal vein, the LT renal vein receives LT adrenal vein superiorly, the LT gonadal vein inferiorly, and lumbar vein posteriorly. (Barry and Brenner 1991)

**2-1-3 Normal variants:**

Aberrant or accessory renal arteries arise off the aorta or iliac arteries anywhere from the level of T-11 to the level of L-4, usually the accessory artery will see coursing into the renal hilum
to perfuse the upper or lower Polar Regions. Preheat arterial branching is a common variant necessary for detection for patients undergoing evaluation for donor nephrectomy (ciffsnote.con/ study guide / Anatomy of the kidney).

The most common anomaly of the LT renal venous system is the circumaortic vein, seen in up to 15% of patients. In this anomaly the LT renal vein bifurcates into ventral and dorsal limb which encircle the abdominal aorta. Less common is the retroaortic renal vein seen in 4% of patients. (Sagger MD 2003)

2-2 Renal physiology:
The kidney participate in whole body homeostasis, regulating acid-base balance electrolyte concentrations, extracellular fluid volume, and regulations the blood pressure. The kidney accomplished these homeostasis functions both independently and in concern with other organ, particularly those of endocrine system. Various endocrine hormones according to indocrine function, these include renin, angiotensin II, aldosterone, antidiuretic hormone, and other.

Many of the kidney functions are accomplished by relatively simple mechanisms of filtration, reabsorption, and secretion, which take place in the nephron. The filtration process take place at the renal capsule is the process by which cell and large protein are filtrated from the blood to the make an ultra-filtrate that will eventually become urine. The kidney generates 180 liters of
filtration in the day, while reabsorbing a large percentage allowing for only generation approximately 2 liters of urine. Reabsorption is the transport of molecules from this ultra-filtrate into the blood, and the secretion is reverse process, in which molecules are transported from the blood into the urine. (ciffsonotes.com \ study guide \ Anatomy of the kidney.).

2-2-1 blood pressure regulation:
Long-term regulation of blood pressure predominantly depends upon the kidney, this primarily occurs through maintenance of the extracellular fluid compartment, the side of which depends on the plasma sodium concentration. Renin is the first in a series of important chemical messenger's that comprise the renin-angiotensin system. (Ciffsonotes.com \ study guide \ Anatomy of the kidney.)

2-2-2 hormones secretion:
The kidney secrete a variety of hormones, include; erythropoietin, and the enzyme renin. Erythropoietin is released in response to hypoxia (low levels of oxygen at tissue level) in the renal circulation.(ciffsonotes.com \ study guide \ Anatomy of the kidney).

2-2-3 Acid-base homeostasis:
Two organ system, the kidneys and the lungs, maintain acid-base homeostasis,
which is the maintenance of **PH** around a stable value. (Ciffsonotes.com \ study guide \ Anatomy of the kidney).

**2-2-4 Excretion of wastes:**
The kidney excrete variety of waste products by metabolism. These include the nitrogenous waste urea, from protein catabolism, and uric acid from nucleic acid metabolism. (Ciffsonotes.com \ study guide \ Anatomy of the kidney).

**2-2-5 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 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 the normal level. (Ciffsonotes.com \ study guide \ Anatomy of the kidney).

**2-3 Renal pathology**
**2-3-1 Renal artery stenosis**
Renal artery disease (RAD) is a cause of chronic kidney disease (CKD) and hypertension, and can be present in patients with other causes of CKD,
such as diabetes or hypertensive nephrosclerosis, and CKD in kidney transplant.

Significant RAD is defined anatomically if there is a >50% stenosis of the lumen by the renal angiography and is usually considered to be hemodynamically if the stenosis exceeds 75% and it may result in renovascular hypertension (RVHT) or ischemic nephropathy. (Saba L Apr 2008)

**Figure 2-3**: Bilateral Renal artery stenosis in 60-year-old patient. Coronal PR image nicely demonstrate an 80% of stenosis in proximal bilateral renal arteries (arrows). (Radiographic.rsna.org)

Atherosclerosis renal artery and renal artery stenosis (RAS) caused by fibromuscular dysplasia are most common primary disease of the renal artery and well known as potential cause of renovascular hypertension. (Leung DA 2002).

Renal artery stenosis is surgically curable case of refractory of accelerating hypertension. Because it rarity (has prevalence of 1% - 5%); noninvasive imaging play an important role in screening high-risk patients. Atherosclerosis is represented for
approximately 60% - 70% of causes and affects the origin or the proximal protein of the renal artery. Fibromuscular dysplasia, neurofibromatosis and radiation are rare causes of renovascular hypertension, (Leung DA 2002).

Atherosclerosis renal artery stenosis tend to affect the more proximal part of renal artery and is most often seen in the middle—age and older population, specially in patient with DM, aortoiliac occlusive diseases, coronary artery disease or hypertension. Fibromuscular dysplasia generally affects the distal part of renal artery and is relatively more common in younger, female population.

A valid diagnostic test of patient suspected having renovascular hypertension is intra—arterial digital subtraction angiography (DSA), which is considered to be the most accurate method for diagnosis renal artery stenosis. However, it is invasive and carries a small risk of series complications such as arterial dissection, or adverse reaction to contrast media. Over the past few decades many report have been published on the diagnostic accuracy of less invasive diagnostic test. (Leung DA 2002).

Noninvasive screen test for RAS include, duplex ultrasound, captopril renography, captopril plasma rennin activity (PRA) test, computerized tomography angiography (CAT), and magnetic resonance angiography (MRA). Computerized tomography angiography (CAT) is the diagnostic method of the choice often the introduction of multidetector computerized tomography (MDCT). (Leung DA 2002).
The objective of CTA is to determine a renal artery patency and characterize the vessel wall, including ostial, postostial, and segmental regions. Equally important is the assessment of parenchymal findings that suggest the presence of hemodynamically significant stenosis. These include renal atrophy, cortical thinning. In both instance, initial unenhanced images can aid diagnoses by detecting calcium, stents, and surgical clips. (Raza SA 2004)

**CTA** with MIP and quantitative measurement of stenosis is an accurate noninvasive technique in the diagnosis of RAS. The advent of spiral and multisection computerized tomography (CT) scanning has made CTA feasible. (Raza SA 2004)

### 2-3-2 Renovascular hypertension (RVHT)
Renovascular hypertension (RVHT) donate nonessential hypertension in which a causal relationship exists between anatomically evident arterial occlusive disease and elevated blood pressure. (Broekhuizen – and deGast HS Jun 2001)
**Figure 2-4**: RT renal artery stent in a 60-year-old man was successfully treated for RVHT. Coronal CT MPR image nicely demonstrates the stent at the origin of the RT renal. (Radiographic.rsna.org)

2-3-3 Renal Artery Aneurysms:
Atherosclerosis is the most common cause of renal artery aneurysm (RAA). Other causes include pregnancy, fibromuscular dysplasia, and neurofibromatosis. Pseudoaneurysm are usually posttraumatic, or inflammatory. (Radiographic.rsna.org)

**Figure 2-5**: LT renal artery aneurysm in 55-year-old woman. Coronal 3D CTA. (Radiographic.rsna.org)
Figure 2-6: LT RAA in 55-year-old women. Axial MIP CTA image shown LT renal artery aneurysm (arrow) (Radiographic.rsna.org)

2-3-4 Renal Arteriovenous Malformation:
Renal arteriovenous malformations (AVMs) are abnormal communications between the intrarenal arterial and venous system. These malformation are either congenital or acquired. Renal AVMs are usually identified during the evaluation of gross hematuria. (Julia R. 2005)
Figure 2-7: an arterial venous malformation of the LT renal artery (LT arrow). And simple cyst of the RT kidney. (Radiographic.rsna.org)

2-3-5 Renal Transplant Evaluation:
CT angiography is also well suited for evaluation of the post-transplant kidney. One relatively common complications after renal transplant is graft renal artery stenois. This has been reported in 3 – 5% of patients, usually within the first 3 years after transplantation. CT angiography can non-invasively image the transplant and document the presence of stenosis. Occasionally, surgical clips can result in artifact near the transplant artery and limit the evaluation. If so, they can be edited from the data set.

Many recent articles have demonstrated the benefit of spiral CT in the evaluation of potential renal donors. When properly performed, this single technique allows delineation of the size, numbers and course of the renal arteries and veins, evaluation of the renal parenchyma and collecting system, and diagnosis of unsuspected conditions that preclude organ donation. CT angiography has been shown to depict 100% of main renal arteries and veins and thus replaced the previously used combination of intravenous urography and renal arteriography at considerable saving of cost and time. Alternatively, MRA is an
effective technique for demonstrating renal vascular anatomy in the patients. (The Russell H.2002)

Figure 2-8: CTA of renal donor MIP image. displaying normal right and left renal arteries. (Radiographic.rsna.org)

To determine if a potential donor is a suitable candidate and to choose the kidney to be harvested, the transplant surgeon must know the number of the renal arteries for each kidney and be aware of the presence of perihilar arteries branching and potential variants in the number and course of the renal veins. (Patrick C 1996).
Figure 2-9: multiple renal arteries in 50-year-old man potential renal donor. Two LF renal arteries are nicely demonstrate in the MIP CTA coronal image. Approximately 15% of healthy people have more than one renal vein. Multiple renal veins and cecum aortico andretro aortic left renal veins of bifid renal veins are easily demonstrated with MDCT. Unusual location or size of lumbar, adrenal and gonadal vein should be reported to avoid potentially life-threatening hemorrhage during renal harvest. (Raza SA 2004)

Living related kidney donor, determining which kidney may be more suitable for transplantation requires a more comprehensive exam. Interpretation of a living related kidney donor, CTA beings with the noncontrast images to identify any calculi or vascular calcifications. Vascular assessment addresses the number, location, patency, and branching pattern of renal arteries and veins, including accessory vessels and normal variants. Parenchymal assessment addresses the presence of masses and scarring in addition to calculating kidney dimensionssuchas length and volume. Finally, through evaluation of the upper and lower...
collecting systems addresses the draining pattern and patency .. (Raza SA 2004)

Renal transplants. Many post-renal transplant patients have multiple surgical clips in the pelvis, which can degree MRI image quality. CTA is therefore an excellent alternative to catheter angiography to assess the renal transplants arteries and veins. The imaging objectives and protocol are similar to RAS evaluation, with two exceptions: Coverage is limited to the pelvis, and acquisition occurs in the angionephrographic phase so that arteries and vein can be evaluated. (Raza SA 2004)

2-4 Renal vein pathology
Involvement of the renal veins with either bland thrombus or tumors, Thrombus is commons indications for evaluation of the renal pedicle.
Renal vein involvement by tumors is crucial in the determination of surgical options for removing a renal tumor. The renal veins are well depicted on the CTA during the corticomedullary or arterial phase of enhancement. Complete IVC opacification usually requires a second spiral acquisition 90 - 120 after injection. Left-sided venous enlargement from spontaneous spleno-renal shunts is sometimes demonstrated in patients with portal hypertension. Rarely venous enlargement can also be demonstrated in patient with high flow state resulting from tumor shunting.

2-5 instrumentations
2-5-1 Ultrasound (Doppler)
Sonography using grayscale imaging, Doppler spectral analysis, and color Doppler imaging is a proven and useful procedure for evaluating the renovascular system. Occasionally, an additional and/or specialized examination may be necessary. While it is not possible to detect every abnormality, adherence to the following guidelines will maximize the probability of detecting most renovascular abnormalities. (Burns PN: 1987).

2-5-2 Magnetic Resonance Angiography (MRA)
MRA also has been extensively evaluated as a method for noninvasively evaluating RAS. MRA can show vascular anatomy and generate an image that is similar in appearance to that obtained by conventional angiography. In contrast to conventional angiography, however, MRA does not require arterial puncture or nephrotoxic agents. In contrast to the traditional physiologic studies for RAS, there is no need to discontinue anti-hypertensive medications, which interfere with the renin-angiotensinsystem, and the accuracy of MRA does not diminish because of renal dysfunction. The similarity of the images generated by MRA and by conventional angiography increases the comfort level of clinicians. There are significant differences in these images, however, and the interpretation of renal MRA requires specific expertise and experience. (Gedroyc WM: 1994)

2-5-3 Digital Subtraction Angiography (DSA)
multiple sequential fluoroscopic images acquired by an image intensifier are electronically converted to digital form and stored. An image obtained before contrast injection, the mask, is electronically subtracted from images containing contrast material. Only the contrast material is visualized. The images are displayed immediately on a 1024 × 1024 matrix screen for review. The DSA Images can be modified via the computer and stored on computer disk or printed.

DSA is sensitive to motion artifact because it involves the subtraction of one image from another. Any movement between images degrades image quality. Patient cooperation is necessary, and carefully titrated conscious sedation is often helpful. (Seldinger SI:1953)

2-5-4 Multi-detectors spiral CT

The Multi-slice CT is the newest form of spiral CT that acquires multiple channels of data from the multiple rows of detectors for each revolution of the x-ray source. Computer generated images in any special plane are easily produced, insuring maximum diagnostic information. Introduced in 1998, multi-detector row CT technology presented key advantage over single-detectors row scanner to improve the
use of the renal CTA. Thinner section (0.63 to 1.5 mm) could be acquired through a similar volume coverage with faster speed. The result has been improved spatial resolution along the Z-axis, reduced breath-hold during procedure, and improved quality of 2D and 3D images. Multi-slice technology has afforded multiphase acquisitions through different physiologic renal state and multi-data set reconstructions from the original scan. (Dirjournal.org/ introduction).

**2-5-4-1 Advantage of Multi-detector CT**
Multidetector CT technology allows faster data acquisition time (average of 2.6 times faster than four-detector row CT) compared with single detector CT, without any loss of image quality. Rapid data acquisition times are possible because of short gantry rotation intervals combined with multiple detectors providing increased coverage along the Z-axis. This combination, along with short interscan delays, allows image acquisitions in multiple phases of renal parenchymal enhancement and contrast material excretion in the collecting system after administration of a single bolus of intravenous contrast material. Timing of the contrast bolus can thus be optimized to evaluate the arterial and venous supply of the kidney as well as the renal parenchyma and collecting system. (Indyrad.iupui.edu)

Another advantage of multidetector CT is improved Z-axis spatial resolution. In multidetector CT, the user selects a specific beam collimation but does not need to choose a particular section thickness in acquisition. Thinner collimation improves the quality
of 3D data set and allows generation of exquisite 3D images of
the renal arteries and veins, comparable with conventional
angiogram and venogram. 3D reformations of collecting system
and potentially obviate conational urography. (Indyrad.iupui.Edu)

2-6 CT Angiographic Technique:
2-6-1 Image Acquisition:
Diagnostic accuracy of renal MDCTA depends on the quality of
initial raw data acquired during the study. Adequate patient
preparation, positioning, as well as the proper contrast material
injection, are of paramount importance. CT protocol for the
evaluation renal vasculature consist of both unenhanced and
enhanced CT scan. Unenhanced scan of the kidney and adrenal
gland with contiguous section of 3-mm thickness are necessary
for the evaluation of adrenal lesions, vascular calcifications and
renal calculi.

2-6-2 Contrast material administration:
Slices with thickness of 1 – 1.5 mm are obtained after injection of
a 100-ml bolus of 300 – 400mg/ml non-ionic contrast at rate of
4ml/s and 70 mg/ml at rate of 5 – 6ml/s in 16 and 64 MDCT
scanner, respectively. Image acquisition is initiated after 4 -5 s
and 6 – 7 s delay in 16 and 64 MDCT scanner, respectively,
when the enhancement of 100 HU is reached within the region of
interest placed on the abdominal aorta. For the evaluation of
renal venous structures and abdominal viscara whole is scanned
with a section thickness 5 mm. Ultimately, in renal donors, 7 – 10
min delayed scan are obtained for the evaluation of the ureters.
2-6-3 Acquisition Parameters :
These include:

- The total spiral / helical scan time, T(sec)
- Slice thickness S, speed of PT table speed, D(mm/sec)
- KVP, MAS values and image reconstruction intervals (mm)

2-6-4 Post Processing Techniques:
Axial source images remain the basic for diagnosis, however, post processes 2D and 3D reformations contribute significantly for accurate evaluation. Most commonly used post-processing technique are multiplaner and curved planner (MPR and CPR), maximum intensity projection (MIP), and volume rendering (VR). MIP image provide angiography like images with an excellent overview of vascular anatomy and their variable projection angles should be used for the accurate interpretation of stenotic lesions. MPR and CPR images are particularly useful for correct evaluation of the arterial luminal diameter for accurate depiction and quantification of the arterial stenosis. VR images can be used for the overall display of the abdominal vasculature and can provide an insight for the interpreter and referring physicians. Finally, the axial images should always be reviewed for possible presence of an accompanying non-vascular pathology. (Euclid Seeram 2001)
2-7 previous studies

Joshi AR professor and heat of radiology Dept 2004 to evaluate renal vasculature using a MDCT. CTA find out that Out of 20 subjects studied: 6 had renal artery stenosis (RAS), 8 were donor, 3 had renal cell carcinoma (RCC) and 1 had Ectopic kidney, and 2 were cases of aortoarteritis with renal involvement. Concluded that the CTA is a good, cost effective and non-invasive modality as it give vascular, anatomic and functional depiction of the kidneys.

Tuncey Hazirolan (university school of medicine, Ankara, Turkey) MDCTA enables, less invasive, accurate, prompt and effective visualization of the renal vessels. MDCTA together with reformatting techniques, can provide valuable information variations including the number, size, course, and anatomy of the renal vascular.

Merchant S, renal vasculature evaluation using MDCTA scanner Indian Radiol Imaging 2004, A brief study of 20 samples find that
in potential living renal donor CTA becomes a fast, non-invasive and cost effective technique for evaluation of renal vasculature as well as function pre-operatively. He take Eight donor in his study. Five had a normal renal vasculature, and three had accessory renal arteries (a normal variant), which becomes surgically very significant. These PT subsequently underwent to DSA and the findings were confirmed and two were declared unfit as donors.

Jeffery C. September, 2006 for renal transplants, CTA therefore an excellent alternative to catheter angiography to assess renal transplants arteries and veins.

Leina Mohamed who had 30 sample underwent CTA found MDCTA proved to be an excellent modality for diagnosis and measurement of the renal arteries in donors. CTA find out that out of 30 subjects studied, 18 male, 12 female. 24 subjects were normal, 3 had double renal artery unilaterally, 1 had triple renal arteries unilaterally, 1 had renal cyst bilaterally, and 1 had AVM. Concluded that the CTA is a good, cost effective and non-invasive modality.

Other study by DR. Hollinger is an assistant professor of radiology found that CTA is a reliable means to define the location, type, and size of RAA as well as the presence of calcification, thrombus, and other renal arterial pathology.
Chapter Three
Material and methods

3-1 Materials

3-1-1 Study population
50 renal donor with age range between (20 – 60) years old with different number of 30 male and 20 female under went to CTA for renal arteries as donor clinically diagnosis free from renal disease. The duration time of this study 4 month

3-1-2 machine used
Toshiba 64 slice (Alamal diagnostic center), and Toshiba 64 slice (Alzaytouna hospital), Siemens 16 slices Sudan advanced center. With specifications and automatic injector machine.

**Figure 3-1** Aquilion 64 slice Toshiba machine

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Siemens 16 slices Sudan advanced Centre</th>
<th>Toshiba 64 slices Alamal diagnostic centre</th>
<th>Toshiba 64 slices Alzaytouna hospital</th>
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<tr>
<td>Collimation</td>
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<td>400 mm</td>
<td>400 mm</td>
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<td>Table speed</td>
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<td>4 mm/sec</td>
<td>3 mm/sec</td>
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<td>Reconstruction</td>
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<tr>
<td>interval</td>
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<tr>
<td>Gantry</td>
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</tr>
<tr>
<td>rotation time</td>
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<td>0.5 sec</td>
<td>0.5 sec</td>
</tr>
<tr>
<td>---------------</td>
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</tr>
<tr>
<td><strong>Contrast</strong></td>
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<td>with CM (omnipaque)</td>
<td>with CM (omnipaque)</td>
</tr>
<tr>
<td><strong>Rate</strong></td>
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<td>5.0 ml/sec</td>
<td>5 ml/sec</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
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<td>800-100 ml</td>
<td>800-100 ml</td>
</tr>
<tr>
<td><strong>Delay time</strong></td>
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<td>8 min</td>
<td>8 min</td>
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<td><strong>Rendering algorithm</strong></td>
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<td>MIP</td>
<td>MIP +VR</td>
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<tr>
<td><strong>MAS</strong></td>
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</tr>
<tr>
<td><strong>No of slices / rotation</strong></td>
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<td>64</td>
<td>64</td>
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</tbody>
</table>

- They were used an automatic injection system (smart prep, bolus triggering and sure star) to ensure optimized contrast monitoring on CTA.

### 3-2 method

### 3-2-1 technique used

### 3-2-1-1 patient preparation
Firstly the patient history should be obtained to identify patients with iodine allergy, renal dysfunction, cardiac disease and asthma, steroid premedication should be administration to those patients with history of iodine allergy or previous reaction to iodinated contrast media. The patient with history of renal dysfunction should be evaluated with creatinine and blood urea nitrogen level, positive contrast media should be administrated.
because they can produce streak artifact lastly patient are instructed on breathing holding techniques and practicing with them before examination because this will help to provide motion free examination.

All 50 patient underwent CTA for renal arteries using the technique bellow

**Table 3-2** The technique used for renal CTA:

<table>
<thead>
<tr>
<th>Machine</th>
<th>Siemans 16 slices</th>
<th>Toshiba64 slices</th>
<th>Toshiba 64 slices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudan advanced center</td>
<td>( Alamal diagnostic Center)</td>
<td>( Alzaytouna hospital)</td>
<td></td>
</tr>
<tr>
<td>PT position</td>
<td>supine</td>
<td>supine</td>
<td>supine</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Slice VR (3D)</td>
<td>supine VR(3D)</td>
<td>supine VR(3D)</td>
<td></td>
</tr>
<tr>
<td>Slice thickness</td>
<td>VR(3D)</td>
<td>VR(3D)</td>
<td>VR(3D)</td>
</tr>
<tr>
<td><strong>Contrast</strong></td>
<td>with CM (omnipaque)</td>
<td>with CM (omnipaque)</td>
<td>with CM (omnipaque)</td>
</tr>
<tr>
<td>Volume</td>
<td>800 – 100 ml</td>
<td>800 – 100 ml</td>
<td>800 – 100 ml</td>
</tr>
<tr>
<td>Rate of injection</td>
<td>Automatic</td>
<td>Automatically</td>
<td>Automatically</td>
</tr>
<tr>
<td>Delay time</td>
<td>12 min</td>
<td>(Sure star) 8 min</td>
<td>(Sure star) 8 min</td>
</tr>
<tr>
<td>Image processing</td>
<td>MIP</td>
<td>MIP</td>
<td>MIP</td>
</tr>
</tbody>
</table>

### 3 -3 Image interpretation
For all 50 patients the length and width of the right and left renal artery arteries were measured electronically, the width measured in the middle of the artery with help of senior technologist.

### 3 -4 Data analysis:
In this study the all data was analysis using Microsoft Excel and statistical package for social sciences (SPSS).
3-5 Ethical considerations:
In this study the data was collected by complete agreement of surgeons and patients.

Chapter Four

Results
All data collected analyzed and tabulated in table and graphs as following:

Table 4-1: Gender distribution

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>20</td>
<td>50</td>
</tr>
</tbody>
</table>
Graph 4-1: show Gender distribution

Table 4-2: Age distribution:

<table>
<thead>
<tr>
<th>Values</th>
<th>Frequencies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-30</td>
<td>33</td>
<td>66%</td>
</tr>
<tr>
<td>31-40</td>
<td>10</td>
<td>20%</td>
</tr>
<tr>
<td>41-50</td>
<td>6</td>
<td>12%</td>
</tr>
<tr>
<td>51-60</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

Graph 4-2: show Age distribution

Table 4-3: show CTA finding:

<table>
<thead>
<tr>
<th>CTA Finding</th>
<th>Frequencies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>44</td>
<td>88%</td>
</tr>
<tr>
<td>Double renal artery unilaterally</td>
<td>4</td>
<td>8%</td>
</tr>
<tr>
<td>AVM</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100%</td>
</tr>
</tbody>
</table>
Graph 4-3: shows CTA finding

Table 4-4: show width measurement of RT and LT renal arteries in cm

<table>
<thead>
<tr>
<th>Values of width in cm</th>
<th>Frequencies of RT renal artery</th>
<th>Frequencies of LT renal artery</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.11 - 0.20</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>0.20 - 0.30</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>0.31 - 0.40</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>0.41 - 0.50</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>0.51 - 0.60</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

Graph 4-4: shows width measurement of RT and LT renal arteries in cm

Table 4-5: show frequency of length of RT and LT renal arteries

<table>
<thead>
<tr>
<th>Values of length in cm</th>
<th>Frequencies of RT renal artery</th>
<th>Frequencies of LT renal artery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1-3.0</td>
<td>35</td>
<td>33</td>
</tr>
<tr>
<td>3.1-4.0</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>4.1-5.0</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>5.1-6.0</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>6.1-7.0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Graph 4-5: show frequency of length of RT and LT renal arteries

Table 4-6: show: The averages of width and length for RT and LT renal arteries

<table>
<thead>
<tr>
<th>Width RT</th>
<th>Width LT</th>
<th>Length RT</th>
<th>Length LT</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Width RT</th>
<th>Width LT</th>
<th>Length RT</th>
<th>Length LT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALE</td>
<td>FEMALE</td>
<td>MALE</td>
<td>FEMALE</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>.32±.07</td>
<td>0.33±.097</td>
<td>.34±.08</td>
<td>0.36±.086</td>
</tr>
</tbody>
</table>

**Table 4-7**: Average width of RT renal arteries according to gender
Average width in male | Average width in female
0.32 | 0.33

**Graph 4-7**: show Average width of RT renal arteries according to gender

**Table 4-8**: Average width of LT renal arteries according to gender
Average width in male | Average width in female
0.34 | 0.36

**Graph 4-8**: show Average width of LT renal arteries according to gender

**Table 4-9**: show Average length of RT renal arteries according to gender
Average length in male | Average length in female

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Graph 4-9: show Average length of RT renal arteries according to gender

Table 4-10: Average length of LT renal arteries according to gender

Average length in male
3.17

Average length in female
2.9

Graph 4-10: Average length of LT renal arteries according to gender

Chapter five
Discussion, conclusion, recommendation

5-1 Discussion:
This study contained 50 donor, 30 male and 20 male, 88% of them is normal and free from any anomalies, 8% had double renal artery and 4% had AVM.

So that the MDCTA succeeded to exclude 6 subject from donation, donors with AVM and the other had double renal arteries. The study found the most age of donation in sample population was range between 20 – 30 years old which comprised 66% of sample population, while the fewest age of donation in range between 50 – 60 years it comprised of 2% of sample population. by compare this result with result made by leina Mohamed 2007 who had 30 samples underwent to CTA, she demonstrated presence of single renal artery bilaterally in 24 subjects, and presence of double RT arteries and single in 3 subject, presence of triple LT renal arteries and single artery in 1 subject, and single renal artery with multiple renal cysts in 1 subject and AVM in 1 also.

Leina Mohamed found that the most age of donation in sample population was range between 15 – 20 years old which comprise 23% of sample population, this is different because she had few range, while the fewest age of donation in range between 45-60 years old it comprise 3% of sample population , here is near to my result .

The most gender of donation in my research was male who comprised 60 % from samples while female comprise 40%
That is same with result of leina Mohamed in spite of randomly collection of data.

Other result in reference that the most width of the RT and LR renal arteries range between 0.31-0.41 cm and had same frequency. Average width of RT renal arteries in male is 0.32 and 0.33 cm in female, and the average width of LT renal arteries in male is 0.34 and 0.36 in female, So these result is nearer to each other. Also found that the most length of the RT and LT renal arteries range between 2.1-3.0 cm, the short length ranged between 2.1-3 cm and the long length is ranged between 6.0-70 cm, which is same with books (renal arteries are usually 4-6 cm in length and 5-6 mm in diameter), the average length of the RT renal artery in male was 3.18 cm and average length in female was 2.9 cm and the average length of the LT renal arteries in male was 3.17 cm and average length in female was 2.9 cm. The study found that average length of male is greater than length in female and the length of the RT renal artery is the longer than the LT renal artery because of the LT renal artery arises below the RT renal artery and has more horizontal orientation, and rather direction upward course to the more superiorly positioned LT kidney. In references the RT renal artery average 2 to 4 cm in length).
5-2 conclusion

The MDCTA is an exam obtained in less time, causing less discomfort for the donor, less pain, no need hospitalization and give accurate information about renal arteries. This study conclude that CTA is best modalities in detecting renal arteries abnormalities, because the evaluation of renal arteries is important to check any abnormalities that can be affect the donor.

The study found that we can evaluate and assessed efficiency, accurate of CTA and diagnostic renal donor by MDCTA. On CTA with 64 slices decrease the time and the radiation dose. Also obtain image quality.

CTA is good, cost effective and non-invasive modality as it gives vascular, anatomic and functional depiction of the kidney.

In this study CTA proved to be an excellent modality for the evaluation, diagnosis and measurement of the renal arteries in donor. As opposed to angiography, MDCT offers information not only regarding the vessel lumen but also wall and the surrounding
structures. The ability to view the data in all 3Dreconstruction constitutes an added advantage.

MDCTA, together with reformatting techniques, can provide valuable information about not only intraluminal pathologies but also the anatomical variations including the number, size, course, and anatomy of the renal vasculature.

In MDCTA, MIP reconstruction is the technique of choice for image presentation because it is able to produce angiography like images, which are easily acceptable to the clinicians. It can discriminate between vessel lumen, wall and calcification. Even small vessel are depicted as long as they have a higher CT number than the surrounding tissues. MIP images were superior to axial and coronal reformatting images, particularly in the diagnosis of ostialstenosis. MIP gives a compound image of likely that allows analysis of differential renal cortical enhancement.

5- 3 recommendations

1. All donors must be send directly to CTA examination except those with hypersensitivity to iodinated contrast media MRA recommended.

2. **MDCTA should** increasingly use as it less invasive, easily applicable and available, MDCTA enables precise visualization of the normal and variant anatomy of the several regions including the renal vasculature.

3. Cooperation between the technologist and radiologist will lead to good image quality and good result.
4. Documentation of donor data is necessary (radiographic investigations) for follow up and for easy reviewing of them.

5. All donors received to CTA examination and no need to do IVU examination before, by MDCTA we can obtain a lot of information's about the urinary system.

6. Obtain modern MDCT scanner (64 slices) in most center of Khartoum state.

7. Future study can be done comparing MDCTA with Doppler ultrasound or in MRA evaluation of renal arteries in donor.

5.4 References


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