SONOGRAPHIC ASSESSMENT OF THE TRANSPLANTED KIDNEY

Thesis

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بسم الله الرحمن الرحيم

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INTRODUCTION AND AIM OF WORK

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The impact of renal transplantation on the management of chronic renal failure during the last decade has been considerable *(Michael et al., 1979).*

Renal transplantation and long term dialysis have both proved to be successful modes of therapy for treatment of chronic renal failure or end-stage renal disease (ESRD). Renal transplantation is the optimal treatment for many patients with ESRD, leading to recovery of normal renal function, cure of the uraemic syndrome, and full rehabilitation from renal disease *(Suresh et al., 1988).*

Renal transplantation is now commonly performed as treatment for chronic renal insufficiency. One year graft survival rates are as high as 80 percent with new immunosuppressive therapy, specially cyclosporine-A. Nonetheless, graft failure remains a substantial problem, particularly in the first few months after transplantation Accurate detection and characterization of significant complications will hopefully sustain and perhaps improve graft survival rates. *(Janis et al., 1987).*

Transplantation from living related donors offers ideal therapy for chronic renal failure.Superior long-term results are obtained by using parental or sibling donors, and the ideal donor is an identical twin. Careful evaluation of a potential live donor is carried out to exclude medical or psychological conditions that may impair the future health of the donor.

Cadaver Kidneys are being increasingly utilized in renal transplantation, because of the difficulty in obtaining live donors. This form of transplantation represents 60 to 70 percent of all renal transplants performed in the United States.

Cadaver Kidneys are obtained under nearly normal physiologic circumstances from patients in whom brain death has been ascertained.

Retrospective studies have shown that recipients between the ages of 16 and 45 years with primary renal disease have the lowest risk for morbidity and mortality. *(Suresh et al., 1988).*

This study is to illustrate the role of ultrasound examination in detection of chronic renal disease and follow up of cases undergoing renal transplantation, also it helps in early detection of complications for example acute tubular necrosis, Rejection with its three distinct types: Hyperacute, acute and chronic rejection, vascular complications either venous or arterial, peritransplant fluid collections presented as a haematoma, abscess, lymphocele.

The non-invasive nature of diagnostic ultrasound allows frequent serial evaluation, and its independence of renal function permits satisfactory visualization in situations where radiographic imaging may be suboptimal *(Michael et al., 1979).*

Review of literature as regards the ultrasonic appearance of the normal and the transplanted kidney will be presented.

Illustrative cases undergoing renal transplantation and some of the complications encountered will be also presented.

SONOGRAPHIC ANATOMY OF THE KIDNEYS

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Ultrasound has become an established and valuable addition to existing diagnostic techniques for the evaluation of the kidneys and other abdominal organs. It is non invasive technique with the ability to outline the contour and position of the kidney, as well as the different shape of soft tissue patterns and different pathological lesions. Unlike urographic techniques in which the anteroposterior diameter of the kidney is not fully appreciated, ultrasound provides information about all three dimensions *(Goldberg et al., 1975).*

Physical principles of ultrasound

The frequency of ultrasound used in diagnostic medicine ranges from 1 to 10 MHz. The resolution varies directly with the frequency used. However, attenuation of the ultrasound beam by tissue also increases with frequency. Limiting the depth to which tissues may be demonstrated by higher frequency waves. In the examination of deeply placed organs, resolution is best at the highest frequency that permits sufficient penetration. In large patients, a 2.25 MHz transducer is necessary, while in thin patients a transducer of 3 or 3.5 MHz can be used. Newborns and young children can often be examined with a 5 MHz transducer.

During a diagnostic examination, a short pulse of ultrasound travels through the transmitting medium at a characteristic velocity for that medium. IF an interface with a medium of different acoustic properties is reached, the ultrasound beam is reflected or refracted. The reflected beam turns to the transducer and is converted into an electric pulse for display. By computer analysis of the time required for the ultrasound to reach and return from the interface, the depth of the tissue interface is determined and displayed *(Christensen et al., 1984).*

Display Modes of Ultrasonography

The reflected echoes may be displayed by A-mode, B-mode, M-mode and B-scan (static and real time).

1. A-mode (Amplitude mode):

In the A-mode, echoes are displayed as vertical deflections along the base line. The height of the vertical deflection is proportional to the amplitude of the detected echo. Therefore the A-mode is amplitude modulated.

The distance between the transducer of the reflecting surface is portrayed in the location of the deflection along the base line. The further to the right the deflection the more distant the reflecting surface will be.

2. B-mode (Brightness mode)

The B-mode display utilizes brightness modulation units representation of echoes.

In this technique, echoes are displayed as illuminated spots along the base line. The brightness of an illuminated spot is roughly proportional to the amplitude of the echo being displayed.

3. M-mode (motion mode)

The M-mode display is used to provide a graphic record of the motion of reflecting surfaces.The greatest use of the M-mode has been in cardiology.

In M-mode the motion of a pulsatile structure is recorded by moving the M-mode tracing across the oscilloscope at preselected speeds.

4. B-scan

A. Static B-scan

The B-scan provides a two dimensional cross-sectional view of anatomy and is therefore sometimes referred to as ultrasonic tomography. The B-scan display is essentially a B-mode display in which the direction of the base line is not horizontal but is constantly variable directly corresponding to the direction of the sound beam leaving the transducer.

B. Real-time scan

Real-time scan techniques provide a way to observe moving structures. The hallmark of these techniques is the very short time required for a complete scan (a mere fraction of a second). Scans are repeated at a rapid rate and continuously displayed on a CRT or television monitor. Depending on the technique employed (whether rotating transducer or multitransducer arrays), the image rates vary from 15 to 150 complete scans per second *(Goldberg et al.. 1975).*

Two basic types of echoes, specular and back scattered echoes, return to the transducer. Specular echoes probably result from a process similar to the specular reflection of light.

These echoes are best appreciated when the reflecting interface is perpendicular to the ultrasound beam. They provide high amplitude echoes from relatively large reflectors such as the interface between organs.

Back scattered echoes are generated from reflecting structures which are small compared with wave length. The amplitude of these low level echoes is independent of the angle of incidence.

Gray scale equipment, by amplifying these low level echoes, permits the demonstration of morphologic details within the parenchyma of organs. The technique used to demonstrate these echoes involves a single pass of the transducer in a line or arc so that each plane of tissues is interrogated only once. This technique is known as sector scanning *(Metrewli, 1980).*

Comparison of image forms

It may be rectangular or sector both have advantages & disadvantages.

The rectangular form has the advantage of good anatomical display from the skin down till the end of the penetrated area, but it has also some drawbacks as the long contact area which will cause more like hood of loosing contact over very curved surfaces,ribs, pelvis and small patients with resultant loss of image, it can not be sharply angulated into certain areas as subdiaphragmatic and pelvic cavity.

While the sector scan has a serious disadvantage of loosing the anatomical detail on both sides of the fan beam but it has also some advantages as the need for small acoustic window so loss of contact is not a problem and scanning of small children is easier also it can be sharply angulated as needed *(Taylor and Hill, 1975).*

DOPPLER ULTRASOUND

Doppler ultrasound supplements the gray-scale examination by permitting the detection and characterization of intra vascular blood flow *(Zaggebski, 1981)*.

The technique is based on the Doppler effect, which states that the frequency of the sound wave reflected by a moving object is different from the frequency of the source. The frequency difference is the Doppler shift, and it increases as the object moves faster. Medical Doppler devices detect the Doppler shifts produced by moving red blood cells in arteries and veins. The Doppler shifts are in the audible range with typical ultrasonic frequencies and blood flow rates. The Doppler signal is the summation of all these shifts and is detected audibly or recorded in a graphic form, usually a spectral analysis (Fig. 1).

Frequency shifts are displayed on the vertical axis, and time is displayed on the horizontal axis. The intensity of any given Doppler frequency is noted by the gray-scale assignment of that frequency. Flow towards the transducer is seen above baseline, whereas flow away is below the baseline. Arterial flow is pulsatile and is maximal during cardiac systole. Veins show little or no pulsatility.

Many of the vessels in the abdomen have characteristics waveforms. Analysis of these waveforms may be helpful in identifying and evaluating the vessels for certain physiologic or pathologic processes *(Taylor et al., 1985)*.

The most common Doppler device used to evaluate the abdominal vasculature is the duplex scanner, ***(Baker, 1987)*** which couples a pulsed Doppler probe to a real-time device. Pulsed Doppler acquires its signal from a discrete area from within the patient and ignores signals from outside of the sample volume. This is helpful particularly in abdominal applications, where vessels overlying one another are commonly placed.

GROSS RENAL ANATOMY

The kidneys are situated in the posterior part of the abdomen, one on each side of the vertebral column behind the peritoneum, surrounded by a "perinephric fat" and renal fascia, *(Gerota's* Fascia). They are extending from the 12th thoracic vertebral body to the 2nd or 3rd lumbar bodies. *(Romane's, 1975).*

Size

The kidneys are usually about the same size; but vary greatly in different individuals. In adults; the length varies between 10 and 15 cm with 5 to 7.5 cm width and 2.5 to 3.5 cm in thickness and weights from 115 to 170 gr. *(Emmett and Witten, 1971).*

The left kidney is little longer, narrower and nearer to the midline. The female kidneys are slightly smaller than in the male *(Simon and Hamilton, 1978).*

A considerable difference in length sometimes due to an anatomical variation, such as a bifid pelvis. The size also varies with the built of the individual, a hypersthenic has a short kidney and a hyposthenic has a long kidney *(Simon and Hamilton, 1978).*

Shape

The kidneys are approximately oval in shape. The medical border of the kidney shows a concavity in the center and is convex towards each pole. The central part (the hilus) is the part through which the renal vein, artery and pelvis of the ureter pass in this order from anterior to posterior.