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# Ultrasound for the Characterization of Renal Masses

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**Abstract:**
Doppler ultrasound of the renal is essential in the assessment and diagnosis of renal masses. There are several diseases involving the renal. Some are functional, diffuse and systematic. Using Doppler imaging provides an assessment of vascular changes which is easily evaluated. Doppler investigation is widely used for assessment of the perfusion of renal arteries. The Doppler indexes; resistive index, pulsatility index, peak systolic are utilized for evaluating the blood flow of the renal arteries. Doppler analysis provides useful diagnostic data that can predict early damage of the kidney tissue. In recent years, ultrasound elastography showed advanced development. It is a new promising technique that is used for assessing the renal tissue characterization. Elastography is an effective imaging for assessing renal carcinogenic. In the future, clinicians can use elastography instead of biopsy.

**Key words: Renal masses, Kidney, Doppler.**

## Introduction:

The detection of renal masses is a common finding when using imaging techniques for different clinical purposes. Most of them are simple cysts that do not require further investigation, but complex cysts and solid masses are also common. Ultrasound (US), contrast-enhanced US (CEUS), computed tomography (CT), and magnetic resonance imaging (MRI) are the most common imaging techniques used to differentiate between benign and malignant lesions and to establish an appropriate management.

In recent decades, there has been a steady increase in the incidental detection of small renal masses (SRMs) [1]. With up to 70% of SRMs ultimately being diagnosed as renal cell carcinoma (RCC), this trend has led to an increase in the overall prevalence of this malignancy. Furthermore, because the majority of incidental cases of RCC are localized to the kidney, there has been an overall downward stage migration associated with this disease [2]. Unfortunately, this has not translated to improved rates of cancer-specific survival, suggesting that many newly

diagnosed cases of SRMs are benign or of low malignant potential and likely do not require treatment [3].

The increasing detection of SRMs has also led to a rise in unnecessary treatment of benign tumors of the kidney, such as oncocytomas and angiomyolipomas (AMLs). This is because these tumors can be difficult to distinguish from renal cancers on the basis of conventional imaging modalities such as ultrasound, computed tomography (CT), and magnetic imaging resonance (MRI) [4,5]. It is estimated that 25% of renal masses of <4 cm are preoperatively misclassified as malignant and are needlessly surgically excised [6,7]. A considerable number of patients could therefore be spared from unnecessary interventions and the associated risk of complications or loss of renal function. Currently, renal mass biopsy (RMB) is considered the gold standard for determining the presurgical histology ofan SRM. Adoption of this diagnostic procedure, however, has been hampered by concerns over a high nondiagnostic rate of 10–15% and 10% erroneous diagnoses due to tumor heterogeneity [8–11]. Additionally, RMB is not always feasible due to the anatomic tumor location, and it remains an intrinsically invasive procedure despite a relatively low complication rate [8,9]. Thus, the vast majority of SRMs are removed surgically without prior knowledge of the tumor's underlying histology.

**Imaging Tools to Characterize Renal Masses:**

Most renal masses are detected incidentally during a baseline US or a CT in the venous phase performed for a non-urological indication. The characterization of these masses (except for the typical simple cyst and fat-containing AML) requires a dedicated CT or MRI study after the administration of intravenous contrast agents. There is no consensus about the protocol for the characterization of renal masses using CT or MRI, but at least an unenhanced phase, a corticomedullary phase (25–70 s after contrast administration), and a venous phase (portal phase or preferably a nephrographic phase at approximately 100 s) are essential to determine the presence or absence of enhancement and to assess some features such as the vascularity [10] (hyper-, iso-, or hypo-enhancement) relative to the adjacent renal parenchyma, homogeneity, or heterogeneity of the enhancement and to determine more precisely whether it is an expansive or infiltrative lesion. Other phases like an excretory phase acquired 3 min after contrast administration are recommended by several authors. This can help in the assessment of the

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relation of the mass with the excretory tract and can help in establishing enhancing patterns of renal masses in different phases.

Regarding the choice of the optimal imaging technique for the characterization of renal masses, the diagnostic performance of CT and MRI is similar when based on the presence and type of enhancement. However, most guidelines recommend the preferential use of CT due to its greater availability, lower cost, better spatial resolution, and quality images without artifacts, and suggest using MRI for challenging cases, as is the case of the detection of a minimal amount of fat or when the lesion enhancement is equivocal [11,12]. However, the absence of ionizing radiation and the supplementary information provided by specific sequences such as diffusion imaging make MRI a more attractive and complete technique, and hence, depending on its availability, it may be considered the first diagnostic option. Moreover, the choice will depend not only on the initially performed test, but also on the experience of each center, with different complementary techniques, possible contraindications, and other patient characteristics. CEUS can also be used in several scenarios [13] with the advantage of real time evaluation, which allows a continuous assessment in all phases, with the additional advantages of lack of radiation and absence of nephrotoxicity of the US contrast agents.

***Renal Cell Carcinoma:***

Renal cell carcinoma is the most fatal of all urologic malignancies and it has a mortality of more than 40%. It accounts for 2- 3% of all adult malignant neoplasms with a male-to-female predominance of 3:2. Renal cell carcinoma is primarily a disease of elderly patients, presenting in between fifth to seventh decades of life. The most common risk factors include; male sex, increased age, smoking; benzene, cadmium, trichloroethylene, asbestos exposure, and chronic dialysis. The majority of cases are believed to be sporadic; the United States National Cancer Institute estimates that only 5% are familial. A number of familial conditions associated with renal cell carcinoma are (familial RCC, hereditary papillary RCC, Von Hippel -Lindau syndrome, and tuberous sclerosis) (14-16).

***Staging of Renal Cell Carcinoma (Robson Classification).*** (17)

Robson Classification; it's the most commonly used routinely because of its simplicity as well as good correlation with the prognosis & indicating specific problems for the surgeon.

- Stage I: limited by the renal capsule.

- Stage II: tumour has breached the renal capsule (perirenal involvement) but is limited by Gerota's fascia.
- Stage IIIa: Tumour extend into the renal vein or inferior vena cava.

  IIIb: involvement of regional lymph nodes.

  IIIc: venous & lymph node invasion.
- Stage IV: Tumors extend to adjacent viscera or distant metastases.

Ultrasound is commonly employed as an initial imaging study due to its relative low cost, relative ease of performance, and lack of need for ionizing radiation. The cornerstone benefit of ultrasonography is its ability to differentiate solid versus cystic renal masses. Historically, there has been concern regarding low sensitivity for detection of small renal masses. (18) However there is evidence that by the hand of expert ultrasonographist, the duplex ultrasonography may be highly accurate in the diagnosis and staging of a large number of renal masses, including those cases where renal vein or caval thrombus are involved. As active surveillance has become an option for selected patients with renal masses, the type of surveillance imaging has become an important issue. A recent study comparing the size of renal masses noted on US, CT, and MRI to the final pathology, demonstrated that all three modalities accurately predicted pathologic tumor size. A number of patients with relatively small renal masses were included in this study as well. (19) However, the use of ultrasound in respect to the identification of lymphadenopathy is limited.

Renal ultrasonography also has a large role in imaging patients with azotemia, pregnant patients, children, neonates and those with severe contrast allergy. Ultrasonography can be quite useful for assessment of renal masses in the intraoperative setting, both for open and laparoscopic cases. In the open cases it may be useful for the identification of relatively small impalpable masses. completely hidden within the renal parenchyma. Laparoscopic ultrasound may be useful in a similar way, and may also be used in concern with different ablative devices that are at times be used in a selected cases of renal masses. (20-22).

**Methods:**

A total of 60 patients with suspicion of renal masses on previous ultrasound study were referred from the urologists and clinicians to our radiology department for CT scan examination seeking for a more definite diagnosis. This study was conducted in the radiology department / Al-

Diwanyh Teaching Hospital, Al-Diwanyh health directorate, during the period from February 2020 to May 2022, Patients referred by Urologist with solid renal masses on preliminary ultrasound.

Data collected using a pre constructed data collection form in which Patients' demographic and clinical data, results of U/S examination findings were recorded .

All these patients were re-examined by Gray Scale and Color Doppler Ultrasound to confirm the presence of renal mass and to determine its benign or malignant features depending on specific characters, echogenicity, shadowing, hypoechoic rim, cystic components, exophytic or not.

The echogenicity of the lesion was graded as hyperechoic if more than that of renal parenchyma, isoechoic if equal to renal parenchyma and hypoechoic if less than that of renal parenchyma. Hypoechoic rim was defined as a surrounding rind of decrease echogenicity surrounding the lesion.

**Results**

Sixty patients referred from the urologists and clinicians with suspicion of renal angiomyolipoma and indeterminate masses; patients were excluded from the study, the age distribution is shown in (table1). The patient's ages ranged from 19 to 69 years.

The gender of the patients participating in this study was; 41 (69.2%) females and 19 (30.8%) males.

Table 1. Age Distribution of the Study Population.

| Age ( year ) | No. | % |
|---|---|---|
| **< 20** | 6 | 1.18% |
| **21 – 30** | 10 | 14.05% |
| **31 – 40** | 15 | 23.01% |
| **41 – 50** | 16 | 35.2% |
| **51 – 60** | 9 | 24.5% |
| **61 - 70** | 4 | 11.9% |
| **Total** | 60 | **100** |

All renal masses were small in size, ranging from 0.6 cm to 3.1 cm, and relatively well defined and rounded, located totally or partially within the renal parenchyma and within the renal capsule.

The ultrasound characters of renal masses shown in (table 2), No mass was reported to be hypoechoic or has calcification on U/S examination.

Table 2. Ultrasound Characters of Renal Masses.

| Characters | | Positive test | Negative test |
|---|---|---|---|
| **Echogenicity** | Hyper-echoic | 39 | 4 |
| | Iso-echoic | 5 | 41 |
| **Shadowing** | | 25 | 35 |
| **Hypoechoic rim** | | 4 | 42 |
| **Intramural cyst** | | 1 | 46 |
| **Exophytic** | | 12 | 31 |

60 patients; 52 patients have solitary renal masses and 8 patients have multiple renal masses; one of them has three masses; two in the right kidney and one in the left and the other two patients showed one in each kidney.

**Discussion:**

CEUS proves useful in determining even minimal vascularity in hypovascularized tumors to differentiate complex renal lesions from solid mass, which are indeterminate on cross-sectional imaging [23]. This is especially advantageous in CKD patients where both complex cysts and tumors have a high incidence [24]. Renal vein invasion: Renal vein invasion by tumor thrombus can be reliably detected by CEUS in which an enhancing thrombus can be seen within the renal

vein and a diagnosis of malignancy can thus be confidently made[25]. Renal infections: Early detection of renal abscesses in a case of acute pyelonephritis can be done by CEUS which shows avascular areas in renal parenchyma in the parenchymal phase. Also, follow-up can be done by CEUS to look for progression or resolution of the disease[26].

Ultrasound contrast agents (USCA) are made up of microbubbles surrounded by a shell. This shell is composed of lipid, protein, or polymer. As these microbubbles are very fragile, the shell provides them with stability [27]. Two principles play a role in CEUS, one is enhancing the echogenicity of the lesion that is imaged and the other is the suppression of the background signal. Contrast agents markedly increase the backscatter due to a large difference in acoustic impedance at gas fluid/tissue surface interface. The second effect of background suppression is achieved by a technique called pulse inversion. For this, two similar signals with opposite phases which are mirror images of each other are sent through the same scan line and echoes from both are collected and added by the transducer. Normal tissues which act like linear reflectors produce no net signal due to the cancellation of echoes whereas the ones having microbubbles act like non-linear reflectors that produce some net signal which stands out against a dark background. When ultrasound waves strike these molecules (tissues with microbubbles), they strongly backscatter and increase the echoes by a factor of 500-1000, thus resulting in enhancement. Microvascular flow rate can also be calculated by calculating the rate at which microbubbles are in the imaging plane. USCA evaluates both the macrovascular and microvascular systems. As soon as the contrast agent is injected, there is an avid and rapid enhancement of the kidney. Initially, the main renal artery and its branches are enhanced, followed by segmental, interlobular, arcuate, and intralobular branches. This is followed by enhancement of the cortex, then the outer medulla, and finally the pyramids. Only two phases are seen, cortical from 15 to 30s and parenchymal from 25 s to 4 min[27-28]. The point to note is that there will be no excretory phase as the contrast agents are not excreted in the kidneys, thus allowing it to use safely in patients with deranged renal function[29,30].

**Conclusions**

Ultrasound is a widely available, approachable, and relatively inexpensive imaging
modality that allows for real-time evaluation of a suspected renal mass without the drawbacks of ionizing radiation and the risk of an MRI. CEUS has several advantages over traditional grayscale ultrasound in the characterization of indeterminate renal masses. It has a distinct value

in the characterization of cystic renal masses and has the potential to differentiate benign from malignant renal masses to some extent. Ultrasound molecular imaging could potentially be an extension of the use of CEUS for serial disease monitoring and longitudinal assessment of treatment response, though it remains in preclinical stages of development at this time.

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