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Diagnostic Accuracy of Ultrasonography in Contrast to Enhanced Computed Tomography Scan in Evaluation of Focal Renal Masses

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ABSTRACT

Background: Focal renal masses need precise characterization with imaging and accurate imaging to distinguish benign lesions and malignancy to establish appropriate clinical management. Aim of the study is to determine the diagnostic accuracy of ultrasonography in comparison with contrast-enhanced computed tomography (CECT) in the evaluation of focal renal masses. **Methodology:** This study was carried out at PAF Hospital, Islamabad, during a period of 5th January 2024 to 30th September 2024. One hundred and ten (110) patients aged 16-60 years with suspected focal renal masses were recruited using non-probability consecutive sampling. Lesions on both modalities were classified as benign and malignant. Quantitative variables were described in terms of a mean and standard deviation and qualitative variables represented frequencies and percentages. Diagnostic accuracy indices such as sensitivity, specificity and positive predictive value, negative predictive value and overall accurate were computed through cross-tabulation. **Results:** The mean age of the patients was 41.68 ± 12.84 years, while the mean mass size was 5.00 ± 1.89 cm. Of the 110 patients, 61 (55.5%) were male and 49 (44.5%) were female. On CECT, 21 (19.1%) lesions were malignant and 89 (80.9%) were benign. On ultrasonography, 26 (23.6) were malignant and 84 (76.4) benign. Cross-tabulation showed 17 true positives, 80 true negatives, 9 false positives, and 4 false negatives. Ultrasonography demonstrated a sensitivity of 80.95%, specificity of 89.89%, positive predictive value of 65.38%, negative predictive value of 95.24%, and overall diagnostic accuracy of 88.18% in detecting malignant focal renal masses. **Conclusion:** Ultrasonography had a good overall diagnostic performance in the assessment of focal renal masses, a high specificity and a negative predictive value. It also seems to be a trusted first line imaging modality to determine the first assessment of renal masses particularly ruling out malignancy. Nevertheless, suspicious or indeterminate lesions only need confirmation by contrast-enhanced computed tomography to determine characterization

INTRODUCTION

In modern clinical practice, focal renal masses are increasingly being identified, particularly due to the extensive use of abdominal imaging both as a means of symptomatic and incidental assessment. In adults, RCC is still the most significant malignant kidney tumor, which presents a significant global burden of cancer[1,2). According to GLOBOCAN 2018, 403 000 cases of renal neoplasm are diagnosed worldwide each year, with 25 4500 cases in men and 148 000 in women. Of these, 175 000 died from the disease, with 114 000 men and 61 000 women [3]. Contrast-enhanced computed tomography has been considered as one of the key imaging modalities used to evaluate indeterminate renal masses due to its ability to give detailed information about the enhancement of the lesions, the composition of the lesions, the local extension, and the local anatomy. It contributes significantly to the detection of solid enhancing masses that are suspicious of malignancy and differentiating them from benign cystic or fat-filled masses [4,5]. Nevertheless, ultrasonography is still of great importance as a primary imaging modality. It is noninvasive, easy to access, relatively cheap, does not use radiation and can be carried out in a general clinical setup. It aids in the initial assessment of the size, location, echogenicity, cystic changes, internal complexity and vascularity of the lesions. Due to these practical benefits, ultrasound can be the initial modality where a renal mass is found, particularly in the resource-limited hospitals in which prompt access to other sophisticated forms of cross-sectional imaging might not be possible [6,7]. In spite of these advantages the conventional ultrasonography is limited in the ability to reliably characterize all focal renal lesions. Lesion size, deep location, the bowel gaseousness, and similarity in the sonographic appearance between

benign masses and the malignant masses could have a negative influence on the diagnostic performance. Recent researches propose that approaches incorporating ultrasound (especially contrast-enhanced ultrasound), have the capacity to enhance the characterization of lesions, even though their performance remains varying in various patient groups and types of lesions [8,9,10].

In that regard, it is clinically significant to assess the performance of the traditional ultrasonography in comparison with the contrast-enhanced computed tomography. Verifying data at local level can help to understand whether ultrasound can be a good first-line modality in triaging focal renal masses and in the diagnosis of patients who will need additional triage by CT.

MATERIAL AND METHODS

This cross-sectional validation study was of prospective design and performed at PAF Hospital, Islamabad, between 05th January 2024 and 30th September 2024. Each patient that appeared with clinical suspicion or the initial imaging indications of a focal renal mass within the timeframe of the study was evaluated in terms of eligibility. The institutional research and ethical review committee of the PAF Hospital, Islamabad granted formal ethical approval to the study before patients were enrolled to the study. All patients received written informed consent before being enrolled. All the participants were informed of the aim of the research, imaging modalities, confidentiality of personal information, as well as the right to leave the study at any point without any implications on the current treatment. The sample size was determined to a diagnostic accuracy at 95 percent confidence interval on a 10 percent desirable accuracy of the sample with expected sensitivity of 76.67 percent, [11] expected specificity of 100 percent [11] and expected prevalence of malignant renal masses at 62.8 percent [12]. Based on this, the sample size of the study was 110 patients. Non-probability consecutive sampling was employed and all the patients that met the selection criteria in the study period were enrolled until the total number was attained.

The study involved patients suspected of having focal renal masses in both sexes and aged between 16 to 60 years. Patients were included if they had an ultrasonography examination and contrast-enhanced CT of the renal lesion. Patients who had a diffuse renal parenchymal disease rather than a focal mass, had undergone renal surgery in the past resulting in significant distortion of the renal anatomy, were severely impaired, a condition that prevented the use of contrast, and had known hypersensitivity to the use of iodinated contrast medium, were pregnant, or had an incomplete imaging history were excluded. Patients where either ultrasonography or CECT was not possible to be done appropriately were also not included in final analysis.

The ultrasonography was done as the first imaging procedure and each lesion was evaluated based on radiological properties. Ultrasonography lesions were classified as malignant when they exhibited imaging characteristics that were suggestive of a solid or predominantly solid renal neoplasm, including a solid or heterogenous echotexture, irregular or ill-defined margins, internal vascularity in Doppler testing or complex architecture suspicious of renal cell carcinoma. Simple cystic lesions, clear margins, anechoic lesions, posterior acoustic enhancement, or other innocent features were classified as benign on ultrasonography. All enrolled patients were then subject to contrast-enhanced CT scan and it was used as a reference standard in the final imaging diagnosis. A lesion was taken to be malignant on CECT when it had features of a renal malignant mass, specifically an enhancing solid renal lesion or a complex enhancing lesion that had the potential to be renal cell carcinoma. Lesions that were considered as simple cyst, complex but benign-appearing cyst, angiomyolipoma, abscess, hematoma, pyelonephritis, or any other non-malignant pathology were classified into benign. To carry out the analysis of diagnostic accuracy of both ultrasonography and CECT, the ultimate results of the two had been further subdivided into two outcome categories only namely benign and malignant.

The presentation and analysis of the data was done on SPSS 25.0. Quantitative data such as age and mass size, were reported as mean and ±standard deviation whereas qualitative data was reported as frequencies and percentages. To compare the results of ultrasound with the results of CECT, a 2x2 contingency table was developed. The sensitivity, specificity, the positive predictive value, the negative predictive value, and the overall diagnostic accuracy of ultrasound were estimated. Potential confounders were stratified to determine the homogeneity of the diagnostic performance among the various subgroups.

RESULTS

The average age of the population sample was 41.68(±12.84SD) years; while, the mean mass size of focal renal mass was 5.00 (± 1.89SD) cm. Regarding age distribution, the largest proportion of patients belonged to the 46–55 years group (30.0%). Patients of the male gender were a little bit more common than females as they constitute 55.5% of the sample. Incidental detection of the renal mass (55.5%), hematuria (18.2%), and palpable flank mass (13.6%) were amongst the most frequent presenting complaint in patients; however, regarding the lesion site, most lesions were found at mid-poles (26.4%). The most common lesions on ultrasonographic lesion characterization included anechoic lesions (46.4%) and the largest morphological group were cystic masses (52.7%). Detailed analysis of all the qualitative variables is presented in table 1.

Table 1

Distribution of qualitative variables (n = 110)

Variable	Category	Frequency	Percent
Age group	16–25 years	15	13.6
	26–35 years	25	22.7
	36–45 years	17	15.5
	46–55 years	33	30.0
	56–60 years	20	18.2
Gender	Female	49	44.5
	Male	61	55.5
Presenting complaint	Hematuria	20	18.2
	Hematuria + flank mass	14	12.7
	Incidental finding	61	55.5
	Palpable flank mass	15	13.6
Pole location	Interpolar/mixed	27	24.5

	Lower pole	27	24.5
	Mid pole	29	26.4
	Upper pole	27	24.5
Echogenicity	Anechoic	51	46.4
	Complex cystic	24	21.8
	Heterogeneous	18	16.4
	Hyperechoic	9	8.2
	Hypoechoic	5	4.5
	Isoechoic	3	2.7
Morphology	Complex cystic	23	20.9
	Cystic	58	52.7
	Heterogeneous	11	10.0
	Solid	18	16.4

The lesions were categorized into benign and malignant divisions and CECT detected 21 malignant lesions and 89 benign lesions, with the malignant rate of 19.1 percent. The ultrasound screened 26 cases as malignant and 84 cases as benign. According to these results, ultrasonography reflected the sensitivity, specificity, PPV and NPV as 80.95%, 89.89%, 65.38%, and 95.24% respectively while the overall diagnostic accuracy was 88.18% in the detection of malignant renal masses (table 2 and table 3). Findings of the CECT and ultrasonography regarding focal renal mass are graphically illustrated in figure 1 and figure 2.

Table 2

Benign and malignant findings on CECT and ultrasonography (n = 110)

Modality	Benign n (%)	Malignant n (%)	Total
CECT findings	89 (80.9)	21 (19.1)	110
Ultrasound impression	84 (76.4)	26 (23.6)	110

Table 3

Cross-tabulation of ultrasound impression against CECT findings with diagnostic accuracy

	CECT Benign	CECT Malignant	Total
Ultrasound Benign	80 (True Negative)	4 (False Negative)	84
Ultrasound Malignant	9 (False Positive)	17 (True Positive)	26
Total	89	21	110

Diagnostic accuracy indices

Sensitivity	80.95%
Specificity	89.89%
Positive predictive value (PPV)	65.38%
Negative predictive value (NPV)	95.24%
Overall accuracy	88.18%

Figure 1

Findings of ultrasound for focal renal masses

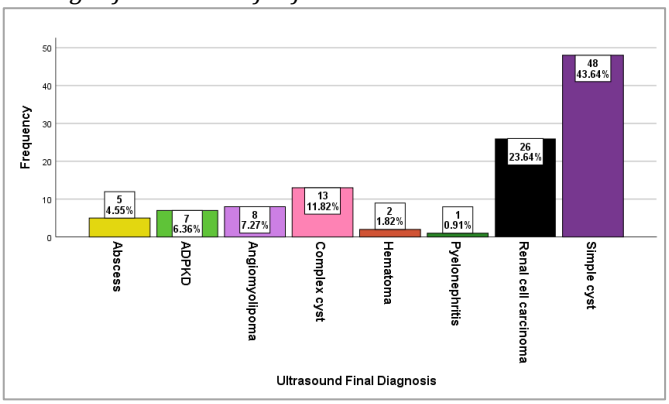
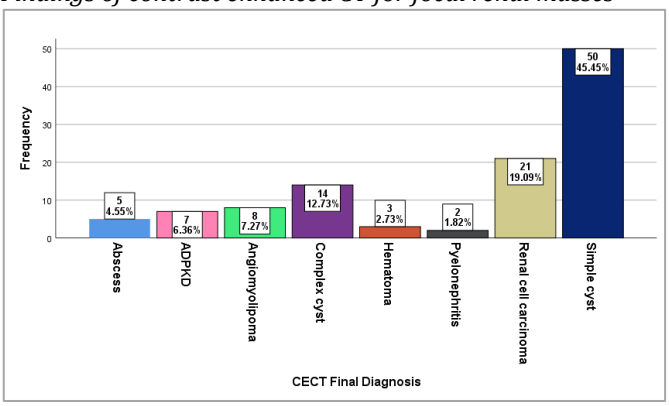


Figure 2

Findings of contrast enhanced CT for focal renal masses



The stratified analysis indicated that there was a difference in diagnostic performance among subgroups. The highest sensitivity was in females and in patients with palpable flank mass but specificity was high in most classes. Nearly all strata had strong negative predictive value which validates the usefulness of ultrasonography as a helpful screening and triage modality of focal renal masses. Nevertheless, variations in positive predictive value were more pronounced, in lower-pole lesions and in certain symptom-related subgroups, which implies that ultrasound can be compromised in its classification of malignancy in the selected clinical contexts (table 4).

Table 4

Stratification analysis of diagnostic performance across confounders

Variable	Category	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
Age group	16–25 years	NA	93.3	0.0	100.0	93.3
	26–35 years	66.7	81.8	33.3	94.7	80.0
	36–45 years	80.0	100.0	100.0	92.3	94.1
	46–55 years	88.9	91.7	80.0	95.7	90.9
	56–60 years	75.0	87.5	60.0	93.3	85.0
Gender	Female	100.0	94.7	84.6	100.0	95.9
	Male	60.0	86.3	46.2	91.7	82.0
Presenting complaint	Hematuria	75.0	91.7	85.7	84.6	85.0
	Hematuria + flank mass	77.8	60.0	77.8	60.0	71.4
	Incidental finding	NA	90.2	0.0	100.0	90.2
	Palpable flank mass	100.0	100.0	100.0	100.0	100.0
Pole location	Interpolar/mixed	50.0	100.0	100.0	96.2	96.3
	Lower pole	80.0	77.3	44.4	94.4	77.8
	Mid pole	100.0	86.4	70.0	100.0	89.7
	Upper pole	71.4	95.0	83.3	90.5	88.9

Note: *NA indicates that sensitivity could not be estimated because no malignant case was present in that subgroup on the reference standard.*

DISCUSSION

The current study compared the diagnostic ability of ultrasonography with contrast-enhanced computed tomography in the examination of focal masses in renal tissues and analysis of the gathered data illustrated that the use of ultrasound was more effective as a first line diagnostic tool especially when the sonographic appearance was that of benign entity and to rule out malignancy. This trend is of clinical interest since the large negative predictive value shows that ultrasonography can contribute to the early triage and decrease the prompt diagnostic inaccuracy of a good number of patients with focal renal lesions.

Our findings generally follow a general trend of imaging literature. Renal masses are being diagnosed more frequently due to the increasing use of abdominal imaging and a significant percentage of lesions are incidentally detected and not suspected clinically [13,14,15]. Incidental detection was the most common presentation in our population as well. This is significant as the contemporary issue does not only lie in the lesion detection but the proper characterization. Imaging has become a significant part of differentiating lesions that are likely to be malignant and need additional work-up to those benign or indolent that possibly can be treated more conservatively [4, 13-15].

The precision in our research was fairly high that indicates that in cases where ultrasound had detected a lesion to be benign it had generally matched well with the CECT results. This is further supported by the interpretation by the strong negative predictive value. These findings can be compared to the already established strengths of the traditional ultrasound at detecting the obviously benign structures like simple cysts which are usually anechoic, have smooth walls, and exhibit enhancement with the sound wave at the back [4,7]. As simple cysts comprised the highest diagnostic group in our data, this probably played a role in the overall high performance of ultrasonography. A research conducted by Kay and Pedrosa highlighted that ultrasound is still especially helpful in situations where simple cystic lesions need to be confirmed as first line rather than cross-sectional contrast imaging evaluation which is used for indeterminate lesions [4]. Systematic review and meta-analysis conducted by Furrer et al. revealed that USG was a promising methodology to assess the renal masses, though the evidence quality was insufficient and more solid data are still required [16]. Likewise, Tufano et al. have documented pooled USG performance of sensitivity estimated to be 94% and overall accuracy of 93% to malignant renal mass, but with more modest specificity [17]. These high numbers cannot be directly compared to our results since our research measured conventional ultrasonography as opposed to CEUS. However, the comparison can be educative: it may indicate that the basic ultra sound can be used to get helpful first-line data, but more sophisticated ultrasound methods can be used to further characterize the data where they are accessible.

Our results can also be largely compared to comparative investigations of ultrasound-based imaging and contrast-enhanced CT. In a head-to-head comparison between US and CECT, Fang et al. established that there was no significant difference between the two modalities in the diagnosis of renal cell carcinoma but limitations of specificity were observed in all cases [18]. The clinical implication involves the fact that ultrasound is not just a screening method; in a few special situations, it will add value to the lesion characterization. Nevertheless, CECT is the more detailed modality since it shows enhancement of the lesion, internal complexity, vascular structure, local extension, and involvement of adjacent organ better as compared to USG. This is the reason why CECT remains as one of the major reference tests in major investigation in imaging of indeterminate renal masses [4,5].

A very critical fact in our study is the imbalance between PPV and NPV. The lesser positive predictive value shows that sonographic impression of malignancy did not necessarily translate to malignancy disease in CECT. This clinically implies that ultrasound can be appropriate in arousing suspicion, but it should not be relied upon individually to categorically determine a renal mass as a malignancy. There are managerial implications here. The false labeling of malignancy can subject the patient to anxiety, further imaging, invasive biopsy or even over treatment. This is a growing concern since a significant number of renal masses removed surgically are benign and modern management strategies are becoming more discriminating, particularly of small renal masses [19,12]. Our findings thus indicate a temperate opinion, indicating that ultrasound proves useful in the initial assessment, yet that diverse actions are necessary to confirm suspicious spots with the assistance of CECT and, in certain cases, histopathology.

Clinical implications of these findings are of particular interest in those clinical environments where there is a possibility of a delay in access to advanced imaging or at least dependency. Ultrasound is cheap, common, portable and does not contain any ionizing radiations. In facilities where CT is scanty, it might be useful as a first-line modality in patients with hematuria, palpable mass or incidentally found renal lesions. Having high negative predictive value can assist in identifying patients where urgent malignancy is not as high, still using CECT on solid as well as heterogeneous, vascular or indeterminate lesions. It is even more compatible with the existing radiologic practice that makes the center of conclusive characterization to be in CT or MRI-based contrasted with ultrasound as an initial assessment tool [4,5,6].

This research has a number of shortcomings. First, it was carried out in only one center and based on a comparatively small sample size, which can be a limitation to generalization. Secondly, CECT was considered as a standard of reference compared to histopathology in all lesions. Although this is reasonable in work on diagnostic accuracy through imaging, it implies that some amount of classification error could still exist, especially in the case of indeterminate or multifaceted cystic lesions [9,10]. Third, ultrasound is operator dependent in nature and this can affect lesion identification and morphology, echogenicity and vascularity interpretation. Fourth, certain subgroup analyses had extremely low numbers of malignants and the resulting stratified sensitivity and predictive figures are to be regarded with care.

CONCLUSION

The ultrasonography showed a good diagnostic tendency in the assessment of focal renal masses, in comparison with contrast-enhanced computed tomography. The modality was highly specific and had a high negative predictive value, therefore, it is effective at least as an initial imaging technique in determining benign lesions and lowering the chances of missed malignancy in everyday practice. It is also noninvasive, readily available, less costly, and does not cause radiation exposure, which adds to its usefulness as a first-line investigation, particularly in a scenario that would require quick and easy access to imaging. Simultaneously, the occurrence of false-positive and false-negative cases in the current study indicates that ultrasonography cannot be regarded as a comprehensive standalone modality that is able to definitively characterize all renal masses. Lesions that are suspicious, complex or indeterminate at ultrasound need furthering evaluation (contrast-enhanced computed tomography). In general, ultrasonography may be an efficient screening and triage picture, whereas CECT should be considered a requisite to confirm and evaluate definitively in terms of malignancy.

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