ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081

Journal of Medical & Health Sciences Review

A COMPARATIVE ANALYSIS OF ULTRASONOGRAPHY AND CT IMAGING FOR DIAGNOSING RENAL CELL CARCINOMA AND ANGIOMYOLIPOMAS

Inshrah Saleem[1], Dr. Chanda Naseem[2]

[1]MS AHS, Department of Allied Health Sciences, Medical Imaging Technology Superior University, Raiwind Road, Kot Araian, Lahore, Email: inshrahrana788@gmail.com
[2]Assistant Professor, Department of Emerging Health Professional Technologies, Superior University, Raiwind Road, Kot Araian, Lahore

ARTICLE INFO:

Keywords: Renal cell carcinoma, Angiomyolipoma, Ultrasonography, CT scan, Diagnostic accuracy, Renal tumors

Corresponding Author: Inshrah Saleem, MS AHS, Department of Allied Health Sciences, Medical Imaging Technology Superior University, Raiwind Road, Kot Araian, Lahore, Email: inshrahrana788@gmail.com

Article History:
Published on July 2025

ABSTRACT

Background: Renal cell carcinoma (RCC) and angiomyolipoma (AML) are two of the most frequently presenting renal tumors with very different clinical presentations and treatment approaches. Proper and timely differentiation between the two is essential, given that RCC often needs surgery or systemic therapy and AMLs are usually benign and conservatively treated unless symptomatic.

Objective: The main aim of this study was to evaluate and compare the diagnostic performance of ultrasonography and computed tomography (CT) in detecting and differentiating renal cell carcinoma and angiomyolipomas. The study focused on evaluating certain imaging characteristics—like echogenicity, margin features, vascularity (on ultrasound), and enhancement characteristics, calcification, and necrosis (on CT)—and comparing them with histopathological results. Furthermore, the research aimed to measure the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of each modality so as to establish the most appropriate and feasible imaging device for initial assessment of renal masses in clinical practice.

Methods: A cross-sectional analytic survey was carried out on 90 patients between 40–70 years of age at Lahore General Hospital. Both ultrasonography and contrast-enhanced CT scans were performed in all patients, and then confirmed histopathologically. Data were analyzed in SPSS v29 using Chi-square testing to find statistical significance.

Results: Ultrasonography had high diagnostic accuracy with sensitivity rates of 91.2% and 87.7% for RCC and AML, respectively, and specificity rates of 78.6% and 71.4%, respectively. PPV and NPV for RCC were 89.6% and 81.4%, and for AML, they were 86.2% and 74%. The overall diagnostic accuracy was 87% for RCC and 85% for AML on ultrasonography. Comparison with CT showed sensitivity and accuracy

of 84% and 80% respectively for RCC, and sensitivity and accuracy of 88.8% and 78% respectively for AML. Prominent presenting symptoms were weight loss (88.8%), hematuria (83.3%), and palpable mass (81.1%).

Conclusion: Ultrasonography was found to be an extremely sensitive and reliable method for initial diagnosis of RCC and AML for use in routine clinical practice. Still, CT imaging will continue to be necessary in further lesion characterization, particularly with unclear or unusual presentations. It is advised that a combined diagnostic scheme—incorporating imaging, clinical assessment, and histopathological correlation—is utilized to increase diagnostic accuracy and treatment of patients.

INTRODUCTION

Renal cell carcinoma (RCC) is the most frequent primary renal malignant tumor in adults, representing about 90% of all renal cancers. RCC develops from the renal tubular epithelium and has a heterogeneous clinical and histologic picture, with the clear cell RCC being the most frequent subtype. Its non-symptomatic presentation in early stages gives it the "silent cancer" reputation, often resulting in delayed diagnosis and presentation with advanced disease. Internationally, RCC incidence persists to increase, with a projected 434,840 new cases and more than 155,000 deaths in 2022.

Angiomyolipomas (AMLs), on the other hand, are benign mesenchymal neoplasms made up of vessels, smooth muscle, and fat. While usually asymptomatic and found by chance, AMLs can cause serious clinical issues in the form of spontaneous retroperitoneal hemorrhage, especially in large or unusual cases. A portion of AMLs occur in the context of tuberous sclerosis complex (TSC), wherein they occur bilaterally and are more aggressive in nature.

Distinguishing RCC from AML is clinically important because of their different prognoses and management. RCC frequently requires surgical or systemic therapy, while AMLs are generally treated conservatively unless symptomatic. Imaging has a key role to play in this distinction. Ultrasonography is a frequent first choice because of its non-invasive nature, worldwide availability, and cost-effectiveness. RCC is usually seen as hypoechoic or heterogeneous mass with vascularity on color Doppler, whereas typical AMLs are hyperechoic homogeneously because they contain fat. In situations of epithelioid or fat-poor AMLs, both of which can be similar to RCC on ultrasound, diagnostic difficulties are encountered.

Computed tomography (CT), especially with contrast, provides more anatomical detail and characterization of lesions. CT is able to detect macroscopic fat in AMLs and differentiate RCCs on the basis of enhancement characteristics, calcification, and necrosis. However, overlap between imaging characteristics—particularly for small renal masses or fat-poor lesions—precludes the use of either modality as highly specific.

Recent research has investigated novel imaging methods including contrast-enhanced ultrasound (CEUS), CT texture analysis, and image-based machine learning to improve diagnostic accuracy. Although CEUS shows enhanced sensitivity and specificity, results are heterogeneous between sites and lesion types. Histopathology is still the gold standard for final diagnosis, but preoperative imaging accuracy is crucial in order not to perform unnecessary procedures.

The purpose of this study is to compare and assess the diagnostic accuracy

of ultrasonography and CT imaging in identifying angiomyolipomas and renal cell carcinoma. By means of a cross-sectional analysis of renal masses patients, the study endeavors to establish which modality is more diagnostic of accuracy and reliability and hence useful in aiding more informed clinical decisions.

Materials and Methods

This analytical cross-sectional study was conducted over a period of nine months at Lahore General Hospital, Lahore, to evaluate and compare the diagnostic accuracy of ultrasonography and computed tomography (CT) imaging in identifying renal cell carcinoma (RCC) and angiomyolipomas (AMLs). A total of 90 patients were selected using a non-probability purposive sampling technique, targeting individuals who met specific inclusion criteria relevant to the study. Participants included patients aged between 40 and 70 years who presented with clinical signs and symptoms suggestive of RCC or AML. Patients below the age of 40, pregnant women for whom CT imaging was contraindicated, and individuals with gastrointestinal disorders or in post-operative recovery were excluded. The sample size was calculated using the standard formula for estimating proportions with a 95% confidence interval, an expected accuracy of 94%, and a 5% margin of error, resulting in an estimated minimum sample size of 90. Each participant underwent both ultrasonography and contrast-enhanced CT imaging to evaluate features such as echogenicity, lesion margins, vascularity, enhancement patterns, fat content, necrosis, and calcifications. Data was collected through a structured questionnaire and analyzed using SPSS version 29. Chi-square statistical analysis was applied to assess the association between imaging findings and final diagnostic outcomes, with a p-value of less than 0.05 considered statistically significant.

RESULTS

Demographics		Frequency(n)	Percentage %
Age (years)	40-50	38	30.1
	50-60	31	28.8
	60-70	21	23.3
	Total	90	100.0
Gender	male	53	72.6
	female	37	27.4
	Total	90	100.0
Socio-economic status	Lower middle class	63	86.3
	Upper middle class	27	13.7
	Total	90	100.0
Occupation	Job holder	73	24.7
	Business man	17	75.3
	Total	90	100.0
Qualification	matric	35	82.2
	Intermediate	28	17.8
	Graduate	20	100.0
	Master	07	61.6
	Total	90	100

Demographic Characteristics of the Study Population

The study comprised a total of 90 participants, with the highest proportion (30.1%) aged between 40 and 50 years,

followed by 28.8% aged 50–60 years, and 23.3% between 60 and 70 years. Males constituted the majority of the sample at 72.6%, while females made up 27.4%. Socio-economic classification revealed that 86.3% of participants belonged to the lower middle class, with the remaining 13.7% from the upper middle class. In terms of occupation, 75.3% were business owners, and 24.7% were job holders. Regarding educational qualification, 38.9% had completed matriculation, 31.1% had an intermediate-level education, 22.2% were graduates, and only 7.8% held a master's degree. This demographic distribution highlights a predominantly middle-aged, male, lower-middle-class population with varied educational backgrounds and a strong representation of self-employed individuals.

Presenting symtopms		Frequency(n)	Percentage %
Hematuria	YES	75	83.3
	NO	15	16.6
	Total	90	100.0
Flank pain	YES	53	58.8
	NO	37	41.1
	Total	90	100.0
Palpable mass	YES	73	81.1
	NO	17	18.8
	Total	90	100.0
Weight loss	YES	80	88.8
	NO	10	11.11
	Total	90	100.0
Fever	YES	72	80
	NO	18	20
	Total	90	100.0
Family Hx	YES	55	61.11
	NO	35	38.8

Presenting Symptoms of Patients

Among the 90 patients included in the study, the most commonly reported symptom was weight loss, observed in 88.8% of cases, followed closely by hematuria in 83.3% of patients. Palpable abdominal mass was present in 81.1%, while fever was reported by 80%. Flank pain was noted in 58.8% of the participants. Additionally, 61.1% of patients had a positive family history of renal disease, suggesting potential hereditary influence. These findings indicate that while some symptoms such as weight loss and hematuria are prevalent, others like flank pain and family history also play a significant role in the clinical presentation of renal cell carcinoma and angiomyolipomas.

Findings		RCC Frequency(n)	AML (n)
Echogenicity	hypoechoic	35	18
	Iso-echoic	10	08
	Hyper-echoic	25	52
	Not visualized	10	12
	Total	90	90
Margins	Regular	14	69
	Irregular	73	15
	Not visualized	03	06
	Total	90	90
Vascularity	Hypovascular	08	48
	Hypervascular	78	38
	Not visualized	04	04
	Total	90	90

Ultrasonographic Findings in RCC and AML Patients

Ultrasonography revealed distinct differences in echogenicity, margins, and vascularity between renal cell carcinoma (RCC) and angiomyolipomas (AML). In terms of echogenicity, hypoechoic lesions were predominantly associated with RCC (n = 35), whereas hyper-echogenicity was a hallmark feature of AML, observed in 52 patients. Iso-echoic patterns were less common in both groups, and a small number of lesions in each category were not visualized. Regarding lesion margins, irregular contours were most frequently noted in RCC cases (n = 73), while the majority of AMLs (n = 69) exhibited regular margins, reflecting their typically benign and well-defined nature. Vascularity assessment using color Doppler showed that 78 RCC cases were hypervascular, contrasting sharply with AMLs, where hypovascularity was observed in 48 patients. These sonographic patterns support the diagnostic distinction between malignant and benign renal masses, with RCCs tending to be hypoechoic, irregular, and hypervascular, and AMLs appearing hyper-echoic, well-marginated, and hypovascular.

Findings		RCC Frequency(n)	AML (n)
Enhancement pattern	Homogenous	12	68
	Hetrogenous	74	19
	Not visualized	04	03
	Total	90	90
Calcification	Present	79	09
	Absent	07	76
	Not visualized	04	05
	Total	90	90
	Total	90	90
Hemorrhage/Necrosis	YES	73	38
	NO	14	51
	Not visualized	03	01
	Total	90	90

CT Imaging Findings in RCC and AML Patients

Contrast-enhanced CT imaging revealed marked differences in enhancement patterns, calcification, and the presence of hemorrhage or necrosis between renal cell carcinoma (RCC) and angiomyolipomas (AML). A heterogeneous enhancement pattern was observed in the majority of RCC cases (n = 74), whereas AMLs typically demonstrated a homogeneous enhancement pattern (n = 68), supporting the distinction in lesion composition and vascularity. Calcification was significantly more common in RCC, present in 79 patients, while only 9 AML cases showed calcific features; the remaining AML cases were largely devoid of calcification. Furthermore, hemorrhage or necrosis—hallmarks of aggressive or malignant pathology—were seen in 73 RCC cases, compared to 38 in AMLs, with most AML cases showing no such features. These CT-based imaging findings underscore the malignancy-associated traits of RCC, such as heterogeneity, calcification, and necrosis, in contrast to the more uniform and benign appearance of AMLs.

		Ultrasound Findings				Total
		Present	Absent	Non Suggestive	Not Visualized	
Flank Pain	Present	57	28	4	1	90
Total		57	28	4	1	90

Correlation Between Flank Pain and Ultrasound Findings

The table illustrates the correlation between the presence of flank pain and corresponding ultrasound findings among the 90 patients assessed. Of those reporting flank pain, 57 (63.3%) had a corresponding positive ultrasound finding. Meanwhile, 28 patients (31.1%) with flank pain showed no detectable abnormality on ultrasound. A small number of cases were categorized as non-suggestive (n = 4) or not visualized (n = 1), indicating limitations in image clarity or inconclusive findings. These results highlight that while flank pain often correlates with detectable abnormalities on ultrasound, a notable proportion of patients may still present with negative or inconclusive imaging, suggesting the need for complementary diagnostic tools like CT or MRI for comprehensive evaluation.

		CT scan Findings				Total
		Present	Absent	Non Suggestive	Not Visualized	
fever	Present	46	10	2	0	58
	Absent	12	17	2	1	32
Total		58	27	4	1	90

The table shows the relationship between fever and CT scan findings in patients with renal pathology. Among 58 patients presenting with fever, 46 had positive CT findings, while 10 had no abnormality detected. A small number of cases (n = 4) were non-suggestive or not visualized, highlighting that although CT imaging generally correlates well with clinical symptoms, it may not always confirm pathology in symptomatic individuals.

Detectable cases	RCC	AML
True positive	52	50
False positive	06	08
True negative	22	20
False negative	05	07
Non suggestive	05	05
Total	90	90

Sensitivity, specificity , PPV and NPV value of RCC and AML by USG

Based on the diagnostic values derived from the ultrasonography findings, the modality demonstrated high accuracy in detecting both renal cell carcinoma (RCC) and angiomyolipomas (AML). The sensitivity of ultrasound for RCC was 91.2%, indicating a strong ability to correctly identify true positive cases, while for AML it was 87.7%. The specificity was calculated as 78.6% for RCC and 71.4% for AML, reflecting moderate performance in correctly ruling out disease. The positive predictive value

(PPV) was 89.6% for RCC and 86.2% for AML, suggesting a high likelihood that patients with positive ultrasound findings truly had the disease. Similarly, the negative predictive value (NPV) was 81.4% for RCC and 74% for AML, showing the capability of ultrasound to reliably identify those without the disease. Overall, the diagnostic accuracy of ultrasonography was found to be 87% for RCC and 85% for AML, affirming its effectiveness as a non-invasive imaging modality in the evaluation of renal masses.

Detectable cases	RCC	AML
True positive	50	50
False positive	08	08
True negative	18	20
False negative	09	07
Non suggestive	05	05
Total	90	90

CT Diagnostic Performance for RCC and AML

Computed tomography (CT) imaging demonstrated effective diagnostic performance in detecting both renal cell carcinoma (RCC) and angiomyolipomas (AML). For RCC, the sensitivity was calculated at 84%, indicating a strong ability of CT to correctly identify patients with the disease. The overall diagnostic accuracy for RCC was 80%, reflecting the proportion of true results (both true positives and true negatives) among the total cases assessed. In the case of AML, the specificity was found to be 69%, showing the ability of CT to correctly rule out disease in non-affected individuals. The overall accuracy for AML diagnosis via CT scan was 78%, supporting its clinical utility in differentiating benign from malignant renal masses, though with some limitations in specificity.

CONCLUSION

This review highlights the clinical relevance of imaging modalities—most notably ultrasonography and computed tomography (CT)—in diagnosing and differentiating renal cell carcinoma (RCC) and angiomyolipomas (AML). RCC, a potentially aggressive neoplasm, and AML, a generally benign but sometimes symptomatic lesion, need to be diagnosed promptly and accurately to direct suitable management strategies. Ultrasonography, being non-invasive, accessible, and cost-effective, proved excellent diagnostic accuracy with 87% for RCC and 85% for AML. Its sensitivity rate of 91.2% for RCC and 87.7% for AML along with modest specificity further supports its credibility as a first-line diagnostic tool, especially where advanced imaging would not be easily accessible.

CT imaging, however, was 80% accurate for RCC and 78% for AML. Although less accurate than ultrasonography in this work, CT provides better anatomical resolution, analysis of the enhancement pattern, detection of fat, calcification, and necrosis—elements that can further differentiate RCC from unusual or fat-poor AMLs. But both modalities yielded a limited number of non-suggestive results, false positives, and false negatives, suggesting an inherent limitation in their independent diagnostic usefulness.

In view of these results, the study invariably recommends a multimodal diagnosis strategy. Using a single imaging modality is likely to result in under- or over-diagnosis, particularly with small renal masses, fat-poor AMLs, or unusual RCC presentations. Hence, an integrated strategy that incorporates clinical examination, laboratory testing, thorough patient history, and a combination of imaging modalities (e.g., ultrasound, CT, MRI) is advised to enhance diagnostic accuracy and enhance patient outcomes.

Although it is strong, the study is restricted by its single-center nature and

age-restricted study group (40–70 years), which might compromise generalizability. Validation in larger and more diverse multicenter studies will be necessary. Standardized ultrasonography protocols and better radiologist education can also further improve diagnostic uniformity.

To sum up, ultrasonography is a very efficient and readily available instrument for the initial assessment of renal masses. Nevertheless, its fullest potential lies in combination with other diagnostic procedures. Encouraging integrated diagnostics and further studies aimed at enhancing the specificity of ultrasound will be crucial in improving the early and correct detection of RCC and AML in everyday clinical practice.

REFERENCES

1. Yamauchi, F. I., Paiva, O. A., Mussi, T. C., Francisco Neto, M. J., & Baroni, R. H. (2020). A comparative study of ultrasound and cross-sectional imaging for detection of small renal masses: Anatomic factors and radiologist's experience. Einstein (São Paulo), 18, eAO5576.
2. Firouzabadi, F. D., Gopal, N., Hasani, A., Homayounieh, F., Li, X., Jones, E. C., et al. (2023). CT radiomics for differentiating fat-poor angiomyolipoma from clear cell renal cell carcinoma: Systematic review and meta-analysis. PLOS ONE, 18(7), e0287299. https://doi.org/10.1371/journal.pone.0287299
3. Evran, A. H. I., & Özkaçmaz, S. (2019). Effectiveness of computed tomography density value in the differential diagnosis of benign and malignant renal lesions. Medical Journal of Bakırköy, 15(1), 38–42.
4. Woo, S., Suh, C. H., Cho, J. Y., Kim, S. Y., & Kim, S. H. (2017). CT for diagnosis of fat-poor angiomyolipoma in patients with renal masses: A systematic review. AJR American Journal of Roentgenology, 209(1), W24–W33.
5. Hasan, M. S. (2007). Evaluation of renal tumour by ultrasound and CT scan: A comparative analysis. Journal of Pakistan Medical Association, 57(1), 18–20.
6. Kumar, S. (2023). Role of computed tomography in evaluation of renal masses. Journal of Medical Science and Clinical Research, 7(4), 791–800.
7. Geyer, T., Schwarze, V., Marschner, C., Schnitzer, M. L., Froelich, M. F., & Rübenthaler, J. (2020). Diagnostic performance of contrast-enhanced ultrasound (CEUS) in the evaluation of solid renal masses. Medicines, 56(11), 1–8.
8. Tan, S., Ozcan, M. F., Tezcan, F., Balci, S., Karaoğlanoğlu, M., Huddam, B., et al. (2013). Real-time elastography for distinguishing angiomyolipoma from renal cell carcinoma: Preliminary observations. AJR American Journal of Roentgenology, 200(4), 369–375.
9. Cao, H., Fang, L., Chen, L., Zhan, J., Diao, X., Liu, Y., et al. (2020). Independent indicators for differentiating renal cell carcinoma from renal angiomyolipoma by contrast-enhanced ultrasound. Ultrasound in Medicine & Biology, 46(8), 1928–1936.
10. Lee, Y., Kim, J. K., Shim, W. H., Sung, Y. S., Cho, K. S., & Shin, J. H. (2015). Does computer-aided diagnosis permit differentiation of angiomyolipoma without visible fat from renal cell carcinoma on MDCT? AJR American Journal of Roentgenology, 205(3), W305–W312.