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DIAGNOSTIC ACCURACY OF ULTRASOUND FOR RENAL TUMORS IN ADULTS TAKING CONTRAST ENHANCED COMPUTED TOMOGRAPHY AS GOLD STANDARD

Original Research

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ABSTRACT

Background: Renal cell carcinoma (RCC) accounts for the majority of renal malignancies in adults, with an increasing global incidence attributed to advances in diagnostic imaging and the growing prevalence of risk factors. Early and accurate detection of RCC is crucial for effective treatment and improved prognosis. Ultrasonography is widely used as a first-line diagnostic tool for renal tumors due to its accessibility, cost-effectiveness, and safety. However, its accuracy compared to computed tomography (CT), the gold standard for RCC diagnosis, remains an area of interest.

Objective: To determine the diagnostic accuracy of ultrasonography in detecting renal tumors in adults, using contrast-enhanced computed tomography as the gold standard.

Methods: This cross-sectional study included 188 participants recruited from the Urology, Nephrology, and Radiology departments of Allied Hospital Faisalabad. Patients with space-occupying lesions detected on grey-scale ultrasound were included, while those with impaired renal function or iodine contrast allergies were excluded. Ultrasound examinations were performed using an Ecostemylab 7 Doppler machine, and CT imaging was conducted with the Siemens CT Somatom Sensation 64 scanner. Patient demographic data, clinical history, and imaging findings were recorded. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using CT as the gold standard.

Results: The mean age of participants was 49.95 ± 10.08 years, with 91.9% males and 8.1% females. Tumor sizes on ultrasound were >4 cm in 3%, >5 cm in 42.4%, and >6 cm in 54.5%, while CT showed >4 cm in 24.24%, >5 cm in 52.2%, and >6 cm in 23.23%. Ultrasound identified 26.3% benign and 73.7% malignant lesions, while CT identified 20.2% benign and 79.8% malignant lesions. Ultrasonography demonstrated a sensitivity of 87.34%, specificity of 80%, PPV of 94.52%, NPV of 61.54%, and overall diagnostic accuracy of 85.86%.

Conclusion: Ultrasonography is a reliable first-line diagnostic tool for renal tumors, demonstrating high diagnostic accuracy. While it is cost-effective and safe, its limitations in specific subgroups necessitate confirmation with CT for comprehensive evaluation.

Keywords: Computed tomography, diagnostic accuracy, nephrology, renal cell carcinoma, renal tumors, sensitivity, ultrasonography.

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INTRODUCTION

Renal cell carcinoma (RCC) is the most common primary malignant tumor of the kidney in adults, accounting for 85–90% of all renal malignancies. These tumors can present as simple, complex, or solid cysts, with simple renal cysts being the most prevalent, particularly in individuals over the age of 50. Simple cysts, often benign, affect approximately half of this population, with a higher prevalence in males and a notable increase in occurrence with advancing age, ranging from 10% under 40 years to 60% in those over 80 years. In contrast, cystic renal malignancies represent 10–15% of all renal tumors (1, 2, 3). The majority of adult kidney cancers, over 80%, are RCCs, characterized as adenocarcinomas originating in the renal parenchyma. Several risk factors, including obesity, hypertension, and cigarette smoking, have been implicated in the development of RCC, with smoking potentially doubling the risk and contributing to nearly one-third of cases (4). In the United States, RCC and renal pelvis tumors rank sixth in cancer incidence among men and ninth among women, accounting for 5% and 3% of all cancers, respectively. The American Cancer Society estimated 76,080 new cases and 13,780 deaths attributed to malignant tumors of the kidney and renal pelvis in 2021, with RCC responsible for approximately 80% of both incidence and mortality (5). The disease often remains asymptomatic in its early stages, with symptoms typically emerging as the tumor progresses. About 25% of patients present with advanced or metastatic disease, often diagnosed incidentally during imaging conducted for unrelated reasons (6). Resistance to chemotherapy and radiation therapy, coupled with a lack of early signs and symptoms, makes RCC particularly challenging to manage. Genetic and environmental factors have been studied extensively, with cigarette smoking, hypertension, and obesity identified as key contributors. Additionally, long-term dialysis and acquired renal cystic disease elevate the risk of RCC, particularly in kidney transplant recipients (7, 8, 9).

RCC is the most lethal malignancy among all urinary tract cancers due to its aggressive progression. While surgical resection remains the primary treatment, nearly half of all patients present with advanced disease at diagnosis, rendering them ineligible for surgery. Postoperative chemotherapy and radiation therapy provide limited survival benefits (10). The classic triad of hematuria, flank pain, and a palpable mass is observed in less than 10% of patients and typically signifies advanced disease. Notably, more than one-third of RCC patients present with locally advanced or metastatic tumors at diagnosis, and among those undergoing surgical resection of localized disease, recurrence rates remain high. Patients with metastatic RCC face a grim prognosis, with a median survival of 13 months and a five-year survival rate below 10% (11, 12). Advancements in imaging techniques have significantly enhanced the diagnosis and staging of RCC. Contrast-enhanced computed tomography (CECT) and contrast-enhanced magnetic resonance imaging (MRI) have become pivotal in characterizing renal tumors. However, concerns regarding ionizing radiation, contrast-induced nephropathy, and high costs limit their widespread use, particularly in resource-constrained settings (13, 14). Ultrasonography, a non-invasive, cost-effective, and radiation-free alternative, plays a vital role in distinguishing cystic from solid renal lesions and detecting renal tumors incidentally. Despite its advantages, including accessibility and safety, ultrasonography is operator-dependent and has limitations in sensitivity, specificity, and spatial resolution (19, 20).

While computed tomography (CT) is regarded as the gold standard for RCC diagnosis, ultrasonography offers significant potential in resource-limited settings or for patients contraindicated for CT imaging due to impaired renal function or contrast allergies. Emerging ultrasound techniques, such as contrast-enhanced ultrasound (CEUS), provide enhanced diagnostic accuracy by reflecting the blood perfusion characteristics of pathological tissues, offering valuable insights for early detection, progression monitoring, and treatment planning (18, 21). The integration of imaging modalities enhances diagnostic precision, with ultrasonography serving as an essential adjunct in clinical evaluation. Given the increasing burden of RCC and the critical need for early and accurate diagnosis to optimize treatment outcomes, this study aims to evaluate the diagnostic accuracy of ultrasonography in detecting renal tumors, using CECT as the gold standard. The findings will help determine the utility of ultrasonography as a first-line diagnostic tool, potentially reducing unnecessary exposure to CT-related risks and facilitating cost-effective diagnostic approaches.

METHODS

The study was designed as a cross-sectional investigation conducted at Allied Hospital Faisalabad. A total of 188 patients were recruited from the Urology and Nephrology outpatient departments as well as the Radiology department. Participants included were those with

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space-occupying lesions identified on grey-scale ultrasound. Patients underwent detailed ultrasonographic examinations followed by preoperative computed tomography (CT) imaging according to the established institutional protocol. Demographic data, clinical history, and imaging findings from both ultrasound and CT were meticulously recorded on a predesigned pro forma. The study aimed to calculate sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of ultrasonography using CT scans as the gold standard. All patients provided written informed consent after a thorough explanation of the study procedures. Eligibility criteria included individuals aged 19 years or older, of both genders, with space-occupying renal lesions detected on grey-scale ultrasound. Patients with compromised renal function or a documented allergy to iodine-based contrast media were excluded from the study to mitigate risks associated with contrast administration.

Ultrasound examinations were conducted by a consultant radiologist utilizing an Ecostemylab 7 color Doppler machine equipped with 3.5, 5, and 7.5 MHz probes. Renal measurements were taken for all patients during these examinations. The CT scans were performed using the Siemens CT Somatom Sensation 64 machine, following standard protocols. Patients were positioned supine on the CT examination table with a full urinary bladder. Scanning was performed from the upper abdomen to the pubic symphysis, with images acquired at a 5-mm interval. The CT imaging provided detailed assessment, serving as the reference for evaluating the diagnostic accuracy of ultrasound. Efforts were made to maintain consistency and accuracy in data collection. Patient demographic information, clinical presentations, and imaging results were systematically recorded on the pro forma to ensure comprehensive documentation. The study design, including the inclusion and exclusion criteria, was structured to minimize potential confounding factors and ensure the validity of the findings.

RESULTS

A total of 99 participants were included in the study, with a mean age of 49.95 ± 10.08 years, ranging from 23 to 75 years. Among the participants, 91.9% were male, while 8.1% were female. Renal tumor sizes measured on ultrasound were consistent with those on computed tomography (CT). On both modalities, 24.24% of participants had tumors larger than 3 cm, 23.23% had tumors larger than 4 cm, and 52.53% had tumors larger than 5 cm. In terms of tumor composition, ultrasound identified cystic masses in 34.4% of participants and solid masses in 65.6%. CT findings revealed 30.3% cystic masses and 69.7% solid masses. Evaluation of echogenicity on ultrasound showed hypoechoic lesions in 44.4%, isoechoic in 20.2%, and hyperechoic in 35.4%. In comparison, CT imaging identified 72.7% hypodense, 20.2% isodense, and 5.1% hyperdense lesions. Borders of the tumors were classified as diffuse in 46.5% and distinct in 53.5% on ultrasound, whereas CT findings indicated diffuse borders in 48.5% and distinct borders in 51.5%. Nodal involvement was detected in 54.5% of participants on ultrasound and 56.5% on CT scans.

Tumor location was also assessed, with ultrasound identifying 30.3% in the lower pole, 35.4% in the middle pole, and 34.3% in the upper pole. Corresponding CT results showed similar findings, with 30.3% in the lower pole, 33.3% in the middle pole, and 36.4% in the upper pole. Diagnostic categorization revealed that ultrasound identified 26.3% of tumors as benign and 73.7% as malignant, whereas CT results categorized 20.2% as benign and 79.8% as malignant. The sensitivity and specificity of ultrasound in detecting renal tumors were calculated as 87.34% and 80%, respectively. The positive predictive value was 94.52%, while the negative predictive value was 61.54%. The overall diagnostic accuracy of ultrasound compared to CT was 85.86%.

Table 1 Age of Participants

Age	
Mean	49.9495
Standard deviation	10.08168
Minimum	23.00
Maximum	75.00

Table 2 Gender of Participants

Gender	Frequency	Percentage
Female	8	8.1
Male	91	91.9
Total	99	100.0

Table 3 Comparison of Tumor Characteristics on Ultrasound and Computed Tomography Among Participants

Tumor Characteristic	Ultrasound (Frequency [%])	CT Scan (Frequency [%])
Size		
> 3 cm	24 (24.24%)	24 (24.24%)
> 4 cm	23 (23.23%)	23 (23.23%)
> 5 cm	52 (52.53%)	52 (52.53%)
Location		
Lower	30 (30.3%)	30 (30.3%)
Middle	35 (35.4%)	33 (33.3%)
Upper	34 (34.3%)	36 (36.4%)
Diagnosis		
Benign	26 (26.3%)	20 (20.2%)
Malignant	73 (73.7%)	79 (79.8%)
Total	99 (100.0%)	99 (100.0%)

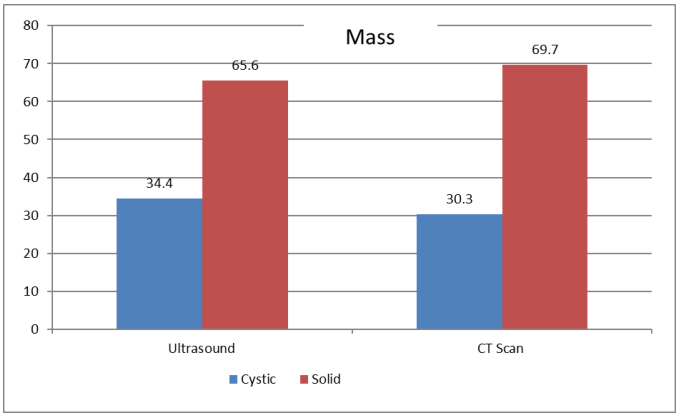

Figure 1 Comparison of Mass in Participants on Ultrasound and on Computed Tomographye

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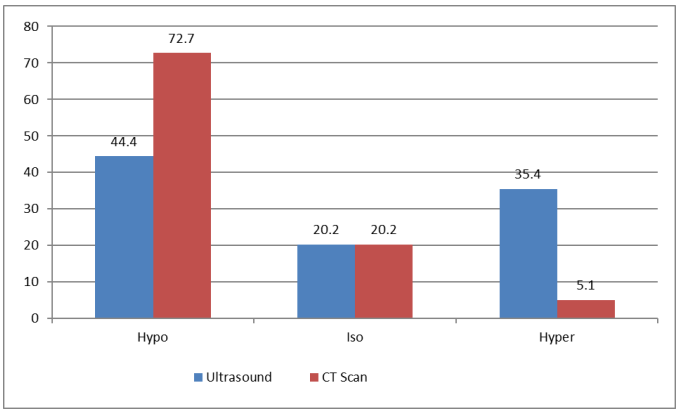

Figure 2 Comparison of ultrasound echogenicity on CT scan and ultrasound

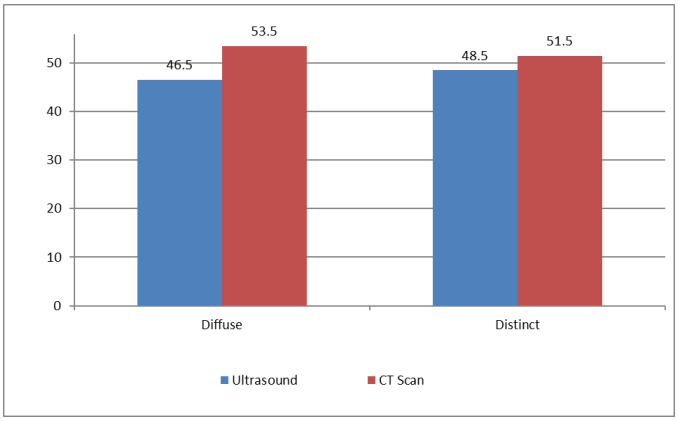

Figure 4 Comparison of Border on Ultrasound and on Computed Tomography among Participants

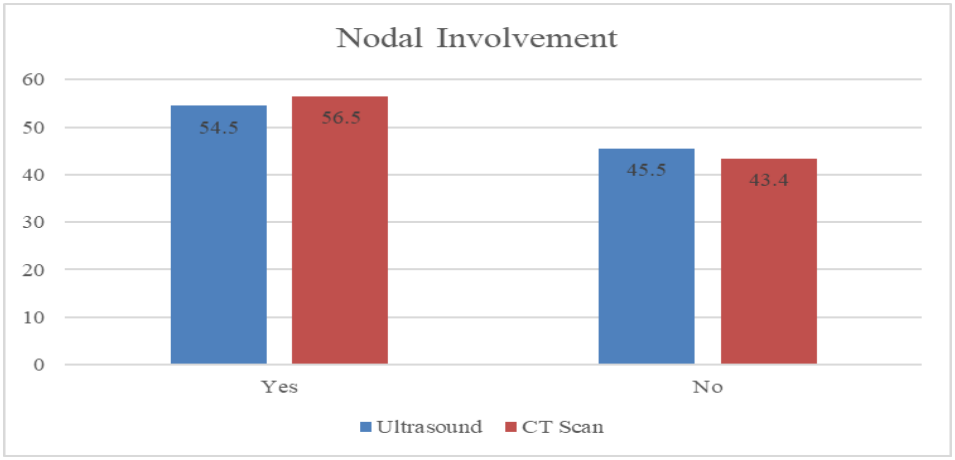

Figure 3 Comparison of Nodal Involvement on Ultrasound and on Computed Tomography among Participants

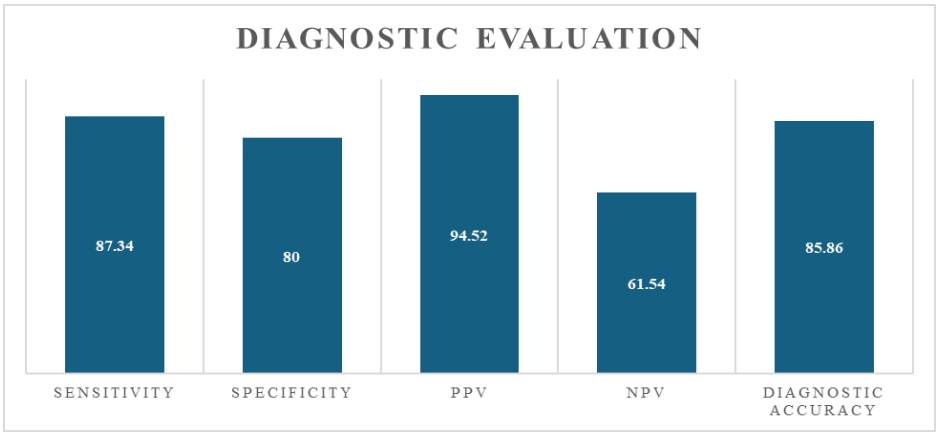

Figure 5 Diagnostic or Screening Test Evaluation of Ultrasound for Renal Tumors in Adults taking Contrast Enhanced Computed Tomography as Gold Standard

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DISCUSSION

The advancements in radiological diagnostic accuracy over the past two decades have significantly improved the early detection of renal cell carcinoma (RCC), particularly smaller tumors. This has contributed to an increase in RCC diagnoses, with higher incidences observed in developed countries due to advanced imaging techniques and better screening programs. In developing nations, the rising incidence may be attributed to growing awareness, the increasing use of imaging for unrelated abdominal complaints, and higher prevalence of risk factors. Early diagnosis of RCC is pivotal, as it allows for timely treatment, symptom management, and improved prognosis. While surgical resection remains the mainstay of treatment, systemic therapies in advanced stages are largely palliative, emphasizing the need for minimally invasive techniques such as partial nephrectomy and tumor ablation using robotic or laparoscopic technologies (18). Computed tomography (CT) remains the gold standard for diagnosing RCC due to its superior sensitivity, specificity, and ability to stage tumors. However, the high cost, ionizing radiation exposure, and risks associated with contrast agents limit its accessibility, particularly in resource-constrained settings. Ultrasonography, in contrast, is a cost-effective, non-invasive alternative that does not involve radiation exposure, making it a valuable initial diagnostic tool. The current study demonstrated the diagnostic accuracy of ultrasonography, with a sensitivity of 87.34%, specificity of 80%, a positive predictive value of 94.52%, and a diagnostic accuracy of 85.86%. These findings underscore the potential of ultrasonography as a reliable modality in the initial evaluation of renal tumors, especially in settings where access to CT is limited. (19)

The study revealed that RCC predominantly affects males, with 91.9% of participants being male. This aligns with previous findings indicating that RCC is more common in males, although survival rates tend to be higher among females. Tumor size evaluation showed consistent results between ultrasound and CT, particularly for larger lesions, which were more frequently detected. However, smaller renal masses (<2 cm) remained challenging to identify with ultrasonography, reflecting its inherent limitations in spatial resolution. These findings highlight the complementary role of ultrasound in RCC diagnosis while emphasizing its limitations in detecting smaller lesions compared to CT and MRI (20). The study findings were consistent with global research, which reported similar diagnostic accuracies for ultrasonography in detecting RCC. However, the sensitivity of ultrasonography was noted to decrease with smaller tumor sizes. Literature has established that while ultrasonography is effective for identifying lesions larger than 3 cm, it is less reliable for smaller lesions, necessitating confirmation with advanced imaging modalities. Despite these limitations, the affordability and widespread availability of ultrasonography make it an indispensable tool, particularly in regions where access to CT and MRI is constrained (21).

The study also observed variations in echogenicity patterns, with hypoechoic lesions being the most common on ultrasound. CT imaging, however, identified a significantly higher proportion of hypodense lesions. These differences may be attributed to the inherent differences in imaging modalities, with CT providing greater tissue contrast and resolution. Tumor characterization, including the assessment of borders, nodal involvement, and tumor location, showed comparable findings between ultrasound and CT, reinforcing the utility of ultrasonography in preoperative evaluations (22). While the study highlighted the strengths of ultrasonography, including its safety, cost-effectiveness, and diagnostic accuracy for larger lesions, its limitations in detecting smaller renal tumors were evident. Additionally, the operator-dependent nature of ultrasonography and its susceptibility to patient-related factors such as body habitus underscore the need for standardized training and protocols to optimize its use. The study also acknowledged the limitations of CT, including radiation exposure and contrast-related risks, further emphasizing the need for advanced imaging techniques like contrast-enhanced MRI to improve diagnostic precision (23).

The findings suggest that ultrasonography holds significant potential as a first-line diagnostic modality for RCC, particularly in resource-limited settings. However, further research is warranted to refine its diagnostic capabilities, particularly for smaller renal masses. Incorporating advanced techniques such as contrast-enhanced ultrasonography and MRI may improve diagnostic accuracy and enable better differentiation between benign and malignant lesions, ultimately enhancing patient outcomes (24, 25).

CONCLUSION

Renal cell carcinoma is increasingly prevalent, emphasizing the importance of timely and accurate diagnostic methods. Ultrasonography serves as a valuable first-line diagnostic tool due to its accessibility, safety, cost-effectiveness, and minimal contraindications. While it demonstrates excellent diagnostic accuracy for renal diseases and is particularly useful in emergency settings, its limitations in certain conditions and patient subgroups necessitate the use of additional imaging techniques. Multi-detector computed tomography, with its superior diagnostic precision, can effectively complement ultrasonography, especially when findings are inconclusive. Together, these

modalities play a critical role in enhancing early detection, guiding treatment decisions, and improving outcomes for patients with renal tumors.

AUTHOR CONTRIBUTIONS

Author	Contribution
Rimsha Maqbool*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Tasra Bibi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Umar Ijaz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Amara Khalid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Bisma Maqbool	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

REFERENCES

1. Khatiwada B, Mahat A, Yadav GK, Duwadi B, Mishra U, Bhusal A, et al. A comparative study of ultrasonography (USG) and computed tomography for detecting ureteric calculi in patients with acute flank pain, and analysis of factors influencing ultrasound detection rates. IJS Global Health. 2024;7(4):e0464.

2. Joseph C. Contrast Material Enhancement in Computed Tomography (CT) Investigation: Lithuanian University of Health Sciences (Lithuania); 2024.

3. Abdulwahab Alqahtani MA, Mohtasib R, Alshehri F, Hadadi I, Alqahtani M, Gareeballah A, et al. Evaluating the Diagnostic Accuracy of Ultrasonography versus Computed Tomography for Detecting Renal Stones. 2024.

4. Khalid T, Farooq SMY, Ali H, Khan A, Mubashir M, Afzal Z, et al. Diagnostic Accuracy Of Ultrasound For The Diagnosis Of Ureteric Stone In Adults Taking Computed Tomography As Gold Standard. Journal of Pharmaceutical Negative Results. 2023:598-602.

5. Diana P, Klatte T, Amparore D, Bertolo R, Carbonara U, Erdem S, et al. Screening programs for renal cell carcinoma: a systematic review by the EAU young academic urologists renal cancer working group. World journal of urology. 2023;41(4):929-40.

6. Cellina M, Cè M, Rossini N, Cacioppa LM, Ascenti V, Carrafiello G, et al. Computed tomography urography: State of the art and beyond. Tomography. 2023;9(3):909-30.

7. Akram F, Mazhar A, Javed H, Fayyaz M, Khan A, Ahmad K. Diagnostic accuracy of contrast enhanced CT for detection of renal cell carcinoma taking histopathology as gold standard. Journal of Ayub Medical College Abbottabad. 2023;35(1):84-7.

8. Siddiqui MA, Ali A, Khalid K, Rabbani MA, Syed FN, Andrabi SAH. Diagnostic Accuracy of Multi-Detector CT for Evaluation of Renal Masses. Pakistan Journal of Medical & Health Sciences. 2022;16(03):253-.

9. Arshad A, Irshad N, Ibrahim A, Yousaf S, Noor S, Nasrullah Z. Diagnostic Accuracy of Magnetic Resonance Imaging in Detecting Clear Renal Cell Carcinoma, Taking Histopathology as Gold Standard. Pakistan Journal of Medical & Health Sciences. 2022;16(07):277-.

10. Amin Z, Zahoor N. DIAGNOSTIC ACCURACY OF CONTRAST ENHANCED CT SCAN IN DIAGNOSING BRONCHOGENIC CARCINOMA, TAKING HISTOPATHOLOGY AS GOLD STANDARD. PJR. 2022;32(4).

11. Spiesecke P, Reinhold T, Wehrenberg Y, Werner S, Maxeiner A, Busch J, et al. Cost-effectiveness analysis of multiple imaging modalities in diagnosis and follow-up of intermediate complex cystic renal lesions. BJU international. 2021;128(5):575-85.

12. Lan Y, Gong T, Zhou R, Wu M, Liu Z. Comparative Study on Diagnosis Value of Contrast-Enhanced Ultrasound and Contrast-Enhanced Computed Tomography after Treating Advanced Renal Cancer Patients with Yiqi Jiedu Decoction. Evidence-Based Complementary and Alternative Medicine. 2021;2021(1):5763618.

13. Granata A, Campo I, Lentini P, Pesce F, Gesualdo L, Basile A, et al. Role of contrast-enhanced ultrasound (CEUS) in native kidney pathology: limits and fields of action. Diagnostics. 2021;11(6):1058.

14. Cantisani V, Bertolotto M, Clevert D-A, Correas J-M, Drudi FM, Fischer T, et al. EFSUMB 2020 proposal for a contrast-enhanced ultrasound-adapted Bosniak cyst categorization–position statement. Ultraschall in der Medizin-European Journal of Ultrasound. 2021;42(02):154-66.

15. Sippola S, Virtanen J, Tammilehto V, Grönroos J, Hurme S, Niiniviita H, et al. The accuracy of low-dose computed tomography protocol in patients with suspected acute appendicitis: the OPTICAP study. Annals of surgery. 2020;271(2):332-8.

16. Njau BK. CT findings in suspected renal colic patients undergoing unenhanced low-dose multi-detector computed tomography: University of Nairobi; 2020.

17. Jin L, Xie F. Untargeted contrast-enhanced ultrasound versus contrast-enhanced computed tomography: A differential diagnostic performance (DDP) study for kidney lesions. Clinics. 2020;75:e1489.

18. Bhund G, Sahito AA, Khoso MH, Memon S, ur Rehman H, Ullah A. Diagnostic Accuracy of Contrast Enhanced Computed Tomography in Detection of Ovarian Cancer in Clinically Suspected Patients. Annals of Punjab Medical College. 2020;14(1):66-9.

19. Beckmann S, Simanowski JH. Update in contrast-enhanced ultrasound. Visceral medicine. 2020;36(6):476-86.

20. Shen L, Li Y, Li N, Zhao Y, Zhou Q, Li Z. Clinical utility of contrast-enhanced ultrasonography in the diagnosis of benign and malignant small renal masses among Asian population. Cancer Medicine. 2019;8(18):7532-41.

21. Rasool M, Pansota MS, Mumtaz F, Saleem MS, Tabassum SA. Positive predictive value (PPV) of computed tomography in diagnosing wilms' tumor using histopathology as gold standard. The Professional Medical Journal. 2019;26(10):1755-9.

22. Munir A, Zameer S, Kalim U. Diagnostic accuracy of contrast enhanced computed tomography in diagnosing renal cell carcinoma, taking histopathology as gold standard. Pakistan Armed Forces Medical Journal. 2019;69(3):644-47.

23. Mei S, Wang M, Sun L. Contrast-enhanced EUS for differential diagnosis of pancreatic masses: a meta-analysis. Gastroenterology Research and Practice. 2019;2019(1):1670183.

24. NAZIR Z, MAQSOOD A, ASGHER MA. Detection of Renal Malignancy on Multi-detector Computed Tomography in Patients Presented with Hematuria. Age (years).53:11.39.

25. Altaf S, Tazeen A, Fatima M, Farooq SMY, Gull Z, Kamran M. Diagnostic accuracy of ultrasound in renal masses taking computed tomography as a gold standard.