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Original Article

Comparative Evaluation of Ultrasonography and Computed Tomography in the Diagnosis of Abdominal Pathologies

Dr Syed Sajad Ahmad [1], Dr Asma Gulzar [2], Dr Fiza Amin [3]

[1]Department of Radiology, Government Medical College Baramulla, J&K, India.
[2]Department of Radiology, Government Medical College Handwara, J&K, India.
[3]Department of Gynaecology & Obstetrics, Ramzaan Hospital, Gogji Bagh, Srinagar, J&K, India.

*Corresponding Author: Dr. Asma Gulzar *asmagulzar199@gmail.com*

Abstract

Background: Abdominal pathologies such as appendicitis, hepatobiliary disease, renal calculi, and bowel obstruction are major causes of acute abdominal pain worldwide. Timely and accurate imaging-based diagnosis plays a vital role in reducing morbidity and guiding clinical management. Ultrasonography (USG) and Computed Tomography (CT) are among the most frequently utilized modalities, each with specific advantages and limitations. ***Objective***: To compare the diagnostic accuracy of USG and CT in detecting common abdominal pathologies in a tertiary care center, and to assess their complementary roles in clinical decision-making. ***Materials and Methods:*** A prospective observational study was conducted involving 200 patients with suspected abdominal pathology. All participants underwent both USG and contrast-enhanced CT within 48 hours. Diagnostic performance parameters (sensitivity, specificity, positive predictive value [PPV], negative predictive value [NPV], and overall accuracy) were determined using surgical, endoscopic, or laboratory confirmation as the gold standard. ***Results***: CT demonstrated superior overall diagnostic accuracy (95%) compared to USG (83%). USG was particularly reliable for hepatobiliary and renal conditions, while CT was markedly more accurate for bowel obstruction and intra-abdominal masses. ***Conclusion***: CT remains the gold standard for diagnosing complex abdominal conditions, but USG serves as an essential first-line imaging modality due to its safety, accessibility, and cost-effectiveness. A stepwise diagnostic approach using both modalities ensures optimal patient care.

Keywords: ***Ultrasonography; Computed Tomography; Abdomen; Diagnostic Accuracy; Sensitivity; Specificity.***

Introduction

Abdominal pain ranks among the most prevalent complaints encountered in emergency departments and outpatient clinics worldwide, contributing significantly to healthcare utilization and hospital admissions. It accounts for a substantial proportion of emergency visits, with studies estimating that it drives approximately 5–10% of all acute care presentations globally [1,2]. The underlying causes of abdominal pain are remarkably diverse, encompassing a broad spectrum of conditions originating from gastrointestinal, hepatobiliary, pancreatic, urinary, vascular, and gynecological systems [3]. Each etiology presents unique diagnostic and therapeutic challenges, necessitating precise and timely identification to mitigate risks of severe complications, prolonged hospital stays, or even mortality [1,3]. The diagnostic process for acute abdominal pain integrates clinical evaluation, laboratory investigations, and advanced imaging modalities, with the latter playing a pivotal role in achieving accurate diagnoses and guiding effective management strategies [2,4].

Historically, the evaluation of abdominal disorders relied heavily on plain radiography and barium contrast studies, which were once considered the cornerstone of abdominal imaging [3,4]. However, these modalities suffer from significant limitations, including low sensitivity for detecting subtle pathological changes, inadequate anatomical resolution, and an inability to identify early inflammatory processes or soft tissue abnormalities [3,4]. The advent of modern imaging technologies has revolutionized the diagnostic landscape, with Ultrasonography (USG) and Computed Tomography (CT) emerging as the primary modalities for assessing acute and chronic abdominal pathologies [5,6,7]. These advanced techniques offer distinct advantages and limitations, influencing their selection based on clinical context, patient characteristics, and resource availability.

Ultrasonography stands out as a versatile, non-invasive, and radiation-free imaging modality, prized for its portability, real-time imaging capabilities, and cost-effectiveness [6,7,8]. These attributes make USG particularly valuable in resource-limited settings and for patient populations where minimizing radiation exposure is a priority, such as pediatric or pregnant patients [8]. USG excels in evaluating hepatobiliary conditions, such as cholelithiasis and acute cholecystitis, as well as renal calculi, ascites, and gynecological pathologies, including ovarian cysts and ectopic pregnancies [7,8,9]. Recent technological advancements, including high-frequency transducers, color Doppler imaging, elastography, and contrast-

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enhanced ultrasound (CEUS), have significantly expanded USG's diagnostic potential [10,11]. These innovations enable detailed assessments of tissue vascularity, stiffness, and perfusion, thereby enhancing the detection of subtle abnormalities [10,11]. Despite its many strengths, USG's diagnostic accuracy is highly operator-dependent, and its efficacy can be compromised in patients with obesity, excessive bowel gas, or anatomical complexities, which may obscure image quality and limit diagnostic yield [6,11].

In contrast, Computed Tomography offers a robust and comprehensive approach to abdominal imaging, characterized by its superior spatial resolution, multiplanar reconstruction capabilities, and high sensitivity for detecting subtle pathological changes [10,12,13]. CT is particularly effective in diagnosing complex conditions such as acute appendicitis, bowel obstruction, hollow viscus perforation, intra-abdominal abscesses, and neoplastic masses, where its ability to visualize free fluid, extraluminal air, and detailed anatomical structures is unparalleled [12,13,14]. The evolution of multidetector CT (MDCT) scanners, coupled with the development of low-dose imaging protocols and iterative reconstruction algorithms, has further refined CT's diagnostic precision while addressing concerns about radiation exposure [10,12,15]. These advancements have solidified CT's role as a cornerstone of abdominal imaging in settings where rapid and definitive diagnoses are critical.

In developing nations, such as India, where healthcare resources, cost considerations, and patient access to advanced diagnostics are often constrained, a stepwise imaging approach is frequently adopted [4,16,17]. In this strategy, USG serves as the initial imaging modality due to its affordability, widespread availability, and lack of ionizing radiation [16,17]. When USG findings are inconclusive or suggest complex pathology, CT is employed as a follow-up modality to provide a more comprehensive evaluation [4,9]. This sequential approach optimizes diagnostic accuracy while minimizing unnecessary radiation exposure and healthcare costs, aligning with principles of resource stewardship and patient safety [16,17,9]. Recent literature emphasizes the complementary roles of USG and CT, advocating for integrated imaging pathways that leverage USG's rapid bedside accessibility and CT's detailed anatomical insights to achieve optimal diagnostic outcomes [4,5,14,18].

The integration of artificial intelligence (AI) and machine learning into abdominal imaging represents a transformative frontier in diagnostic radiology [15,19,20]. AI-driven tools are increasingly capable of performing automated organ segmentation, detecting lesions, and providing predictive analytics to support clinical decision-making [15,19]. These technologies hold the potential to reduce reporting times, standardize diagnostic interpretations, and enhance accuracy across diverse patient populations, particularly in settings with varying levels of radiologist expertise [15,19]. For instance, AI algorithms can assist in identifying subtle findings, such as early inflammatory changes or small neoplastic lesions, that might be overlooked in complex cases [20]. However, the efficacy of imaging modalities, whether augmented by AI or not, continues to depend on operator expertise, patient-specific factors (e.g., body habitus, clinical presentation), and the clinical context in which imaging is performed [20,21].

He primary objective of this study is to rigorously evaluate the diagnostic performance of USG and CT in the context of common abdominal pathologies, with a focus on their complementary roles in a tertiary-care setting. By systematically comparing the diagnostic accuracy, sensitivity, and specificity of these modalities and correlating their findings with clinical, radiological, and surgical outcomes, this study aims to provide evidence-based recommendations for optimizing imaging pathways. These recommendations will address the judicious use of USG and CT in both acute and chronic abdominal conditions, with an emphasis on improving diagnostic efficiency, reducing unnecessary imaging, and enhancing patient outcomes in diverse clinical scenarios.

Aims and Objectives
To compare the diagnostic accuracy of USG and CT in detecting common abdominal pathologies in a tertiary care center, and to assess their complementary roles in clinical decision-making.

Materials and Methods

Study Design and Setting
A prospective observational study was conducted in the Department of Radiology, in our hospital, from January 2023 to December 2024.

Sample Size
A total of 200 patients (≥18 years) with suspected abdominal pathology were included. The sample size was determined based on previous literature estimating an 85–95% diagnostic accuracy for CT and 70–85% for USG, with 80% power and 5% significance level.

Inclusion Criteria
- Adults presenting with acute or chronic abdominal pain or palpable mass
- Patients who underwent both USG and CT within 48 hours
- Availability of surgical, laboratory, or endoscopic confirmation

Exclusion Criteria
- Pregnant women
- Patients with contraindications to iodinated contrast
- Inadequate or incomplete imaging studies

Imaging Protocols

Ultrasonography
Performed using a GE LOGIQ P9 machine with a 3.5–5 MHz curvilinear probe and 7.5–10 MHz linear probe. Standard scanning of the liver, gallbladder, pancreas, kidneys, spleen, bowel, and pelvis was performed in supine and left lateral positions.

Computed Tomography (CT)
CECT scans were obtained using a 128-slice Siemens Somatom MDCT scanner. Imaging parameters: slice thickness 5 mm, 120 kVp, 200–250 mAs. Intravenous contrast (Iohexol 300 mg/mL, 1.5 mL/kg) was administered at 3–4 mL/sec. Oral contrast was given in bowel-related cases.

Data Interpretation
All images were independently interpreted by two radiologists (each with >5 years of experience) who were blinded to each other's findings. Disagreements were resolved by consensus.

Reference Standard
Final diagnoses were confirmed via surgical, histopathological, endoscopic, or biochemical findings.

Statistical Analysis
Statistical analysis was performed using SPSS v26. Sensitivity, specificity, PPV, NPV, and accuracy were calculated for each modality. Chi-square testing was applied for group comparisons; p

< 0.05 was considered statistically significant. Inter-observer agreement was evaluated using the kappa (κ) coefficient.

Results

Demographics

Among 200 patients included in the study, 110 (55%) were males and 90 (45%) females, with a mean age of 43 ± 14 years (range 18–78 years). Most patients presented with acute right lower quadrant or epigastric pain (65%), followed by generalized abdominal distension (18%) and fever with localized tenderness (12%).

The table 1 summarizes the frequency and percentage distribution of major abdominal pathologies diagnosed among the study population. Acute appendicitis was the most common finding, followed by liver abscess and cholelithiasis. Males demonstrated a higher prevalence of appendicitis and liver abscesses, whereas females showed more cases of cholelithiasis. Elderly patients (>60 years) accounted for most intra-abdominal masses.

USG provided definitive diagnoses in 160 of 200 cases (80%), whereas CT provided definitive diagnoses in 190 of 200 cases (95%). In 25 cases, USG findings were equivocal and required CT correlation for confirmation, particularly in bowel obstruction and pelvic mass lesions.

Table 1: Distribution of Diagnoses

Pathology	Number of Patients (%)
Acute appendicitis	50 (25%)
Liver abscess	40 (20%)
Cholelithiasis	36 (18%)
Renal calculi	30 (15%)
Bowel obstruction	24 (12%)
Intra-abdominal mass	20 (10%)

Subgroup Trends

Males had a higher prevalence of appendicitis and liver abscesses, whereas females showed more cases of cholelithiasis. Elderly patients (>60 years) accounted for most intra-abdominal masses.

USG provided definitive diagnoses in 160/200 cases (80%), whereas CT provided definitive diagnoses in 190/200 cases (95%). In 25 cases, USG findings were equivocal and required CT correlation for confirmation, particularly for bowel obstruction and pelvic masses.

The table 2 compares the diagnostic performance parameters—sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy—of USG and CT for various abdominal pathologies.

Table 2: Diagnostic Performance of USG vs CT

Pathology	Modality	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Appendicitis	USG	81	86	85	83	84
	CT	97	98	97	98	97
Liver abscess	USG	89	91	90	90	90
	CT	96	97	96	97	96
Cholelithiasis	USG	91	93	92	92	92
	CT	96	97	96	97	96
Renal calculi	USG	86	89	87	88	88
	CT	98	98	98	98	98
Bowel obstruction	USG	76	81	78	79	78
	CT	95	96	95	96	95
Intra-abdominal mass	USG	72	83	75	80	78
	CT	94	96	94	96	95

CT demonstrated superior diagnostic accuracy across most pathologies, particularly for appendicitis, bowel obstruction, and intra-abdominal masses. The difference between USG and CT diagnostic accuracy was statistically significant ($p < 0.001$) for all pathologies except cholelithiasis ($p = 0.08$), where both modalities performed comparably. Inter-observer agreement was high for both modalities (κ = 0.89 for CT, κ = 0.82 for USG).

Observational Highlights

- USG missed 5 cases of appendicitis (obscured by bowel gas) and 4 cases of small bowel obstruction.
- CT misclassified 2 small hepatic cysts as abscesses, resulting in minor false positives.
- Mean scanning time was shorter for USG (≈10 minutes) compared to CT (≈20 minutes).
- Radiation dose for CT averaged 4.2 ± 0.5 mSv, within recommended diagnostic limits.

Discussion

The current study provides robust evidence that computed tomography (CT) consistently surpasses ultrasonography (USG) in diagnostic accuracy for a wide range of abdominal pathologies, particularly appendicitis, bowel obstruction, and intra-abdominal masses [21]. This finding aligns with a growing body of international and Indian research that underscores CT's superior diagnostic capabilities, driven by its high spatial resolution, ability to generate detailed cross-sectional images, and capacity to detect subtle inflammatory, vascular, and structural abnormalities that may be missed by other modalities [22]. In our cohort, CT achieved a diagnostic accuracy of 95%, significantly outperforming USG, which recorded an accuracy of 80% [23]. These results corroborate a large-scale study conducted by Singh et al. involving 500 Indian patients, which reported diagnostic accuracies of 93% for CT and 82% for USG, highlighting the consistency of CT's performance across diverse populations [23]. The enhanced visualization offered by CT, including its ability to delineate complex anatomical relationships and pathological changes, makes it an indispensable tool in the diagnostic armamentarium for acute abdominal conditions [22].

In contrast, USG demonstrates particular strengths in the evaluation of hepatobiliary disorders, such as cholelithiasis and liver abscesses, where it achieved a diagnostic accuracy of 92% in our study [24]. This high accuracy reinforces USG's well-established role as the first-line imaging modality for gallbladder and liver pathologies, owing to its real-time imaging capabilities, lack of ionizing radiation, and widespread availability in clinical settings [25]. The ability to perform USG at the bedside, without exposing patients to radiation, makes it especially valuable in resource-limited settings and for populations where radiation risks are a significant concern, such as pediatric and pregnant patients [26]. For instance, USG's ability to rapidly assess gallbladder wall thickening, pericholecystic fluid, or liver parenchymal changes provides critical diagnostic information without the need for more invasive or radiation-intensive procedures [25]. These attributes position USG as a cornerstone of hepatobiliary imaging, particularly in scenarios where patient safety and accessibility are paramount [26].

For the diagnosis of acute appendicitis, CT exhibited a sensitivity of 97% and specificity of 98%, markedly outperforming USG, which recorded a sensitivity of 81% and specificity of 86% [27]. These findings are consistent with meta-analyses that report pooled sensitivity and specificity values for CT exceeding 95%, underscoring its reliability in detecting appendicitis [27]. CT's superiority in this context stems from its ability to visualize critical diagnostic features, such as periappendiceal fat stranding, abscess formation, and perforation, which are often obscured on USG due to interference from bowel gas, patient body habitus, or operator variability [28]. For example, CT's cross-sectional imaging allows clinicians to accurately identify the inflamed appendix and assess complications, such as perforation or phlegmon, which are crucial for guiding surgical or conservative management [28]. These advantages make CT the preferred modality for confirming appendicitis, particularly in cases where clinical presentation is atypical or USG findings are inconclusive [27].

Similarly, in the evaluation of bowel obstruction, CT demonstrated a diagnostic accuracy of 95%, compared to 78% for USG [29]. CT's ability to precisely localize the transition point, assess the severity of obstruction, identify underlying etiologies (e.g., adhesions, hernias, or tumors), and detect complications such as ischemia or strangulation provides unparalleled diagnostic clarity [29]. These capabilities are critical in acute surgical settings, where timely and accurate identification of the obstruction's cause and severity can significantly influence treatment decisions, such as the need for urgent surgical intervention versus conservative management [29]. USG, while useful for initial assessment, is limited by its inability to consistently visualize deep-seated structures or provide a comprehensive evaluation of the bowel, particularly in obese patients or those with significant bowel gas [28]. Consequently, CT remains the gold standard for bowel obstruction, offering a level of detail that directly informs clinical decision-making [29].

Our findings also highlight the value of sequential imaging strategies, particularly in resource-constrained environments where cost and accessibility are critical considerations [30]. By employing USG as an initial screening tool, clinicians can perform rapid, non-invasive bedside assessments to guide preliminary diagnoses [30]. In cases where USG yields equivocal or inconclusive results, CT can be used as a follow-up modality to provide a more comprehensive evaluation, thereby optimizing diagnostic accuracy while minimizing unnecessary radiation exposure and costs [21]. This sequential approach not only enhances patient safety but also aligns with evidence-based guidelines that advocate for judicious use of imaging resources in low-resource settings [30].

The integration of artificial intelligence (AI)-assisted imaging represents a transformative advancement in diagnostic radiology, with the potential to further enhance the performance of both CT and USG [22]. Recent studies have demonstrated that machine learning algorithms can improve detection rates for appendicitis, bowel lesions, and hepatobiliary pathologies while reducing interpretation time and mitigating operator dependency [23]. For instance, AI tools can standardize USG interpretation by identifying subtle findings that may be overlooked by less experienced operators, thereby improving diagnostic consistency [24]. Moreover, AI-driven analysis of CT images can enhance the detection of complex pathologies, such as early-stage malignancies or ischemic changes, by highlighting patterns that may not be immediately apparent to the human eye [23]. These advancements hold significant promise for improving diagnostic workflows, particularly in high-volume or understaffed clinical settings [24].

Despite its superior accuracy, CT is not without limitations, including the risks of radiation exposure and contrast-induced nephropathy, particularly in vulnerable populations such as children, pregnant women, and patients with renal impairment [25]. To address these concerns, recent advancements in low-dose CT protocols and iterative reconstruction techniques have significantly reduced radiation exposure without compromising image quality [26]. Careful patient selection and risk-benefit assessments are also critical to minimizing adverse effects, ensuring that CT is used only when clinically justified [25]. Conversely, USG's limitations include its dependence on operator expertise, challenges in imaging obese patients or those with excessive bowel gas, and reduced sensitivity for deep-seated or retroperitoneal lesions [27]. These shortcomings highlight the complementary nature of CT and USG, emphasizing the need for a tailored imaging approach that considers patient-specific factors, such as age, clinical presentation, and comorbidities[28].

Emerging hybrid imaging paradigms, such as contrast-enhanced ultrasound (CEUS) combined with CT or functional imaging techniques, offer promising avenues for improving diagnostic accuracy [29]. By integrating the real-time, radiation-free advantages of USG with the comprehensive anatomical detail provided by CT, these approaches can enhance early detection, guide interventional procedures, and improve risk stratification in acute abdominal emergencies [30]. For example, CEUS can provide dynamic assessments of vascularity and tissue perfusion, complementing CT's static anatomical images and potentially reducing the need for contrast-enhanced CT in certain cases [29]. Such hybrid strategies are particularly valuable in complex cases, where a single modality may not provide sufficient diagnostic clarity[30].

In clinical practice, a structured imaging algorithm that employs USG as the first-line modality, followed by CT in inconclusive or complex cases, offers a balanced approach to diagnostic efficacy, patient safety, and cost-effectiveness [21]. For hepatobiliary disorders, USG remains the gold standard due to its high sensitivity and accessibility [25]. However, for suspected appendicitis, bowel obstruction, perforation, or intra-abdominal masses, CT is indispensable due to its unmatched diagnostic precision [22]. The incorporation of emerging AI tools and low-dose CT protocols is likely to further refine these diagnostic pathways, enhancing efficiency while maintaining or improving accuracy [23,24]. As imaging technology continues to evolve, the integration of advanced modalities and decision-support tools will play a pivotal role in optimizing the management of acute abdominal conditions.

Conclusion

CT demonstrates significantly higher diagnostic accuracy compared with USG for most abdominal pathologies, particularly bowel obstruction, appendicitis, and intra-abdominal masses. However, USG remains indispensable as a first-line, rapid, and radiation-free modality. A hybrid diagnostic pathway utilizing USG initially and

CT for confirmation or surgical planning ensures optimal diagnostic performance while maintaining patient safety and cost-effectiveness.

Declarations

Ethics approval

The study was reviewed and approved by the ethical committee of our institute.

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Conflict of interest

None declared

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