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DIAGNOSTIC ACCURACY OF MAGNETIC RESONANCE IMAGING VERSUS COMPUTED TOMOGRAPHY IN EVALUATION OF ACUTE APPENDICITIS: A CROSS-SECTIONAL STUDY

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Abstract

Introduction: Acute appendicitis represents the most common surgical emergency, with diagnostic challenges leading to high misdiagnosis rates and unnecessary surgeries. While computed tomography has become the imaging gold standard, radiation exposure concerns have prompted investigation of magnetic resonance imaging as a viable alternative. This study aimed to compare the diagnostic accuracy of MRI versus CT in evaluating suspected acute appendicitis.

Methods: A prospective cross-sectional study was conducted at Santosh Medical College & Hospital, Ghaziabad, from July-December 2012. One hundred seventy-five patients aged 16-65 years with clinically suspected appendicitis underwent both contrast-enhanced CT and MRI examinations within six hours. Blinded radiologists interpreted images using standardized protocols. Final diagnosis was established through surgical findings, histopathological examination, or clinical follow-up.

Results: Of 175 patients, 108 (61.7%) had confirmed appendicitis. CT achieved sensitivity of 96.3%, specificity of 88.1%, and overall accuracy of 93.1%. MRI demonstrated sensitivity of 93.5%, specificity of 91.0%, and overall accuracy of 92.6%. No statistically significant differences existed between modalities across all performance metrics ($p>0.05$). ROC analysis revealed comparable diagnostic performance with area under curve of 0.923 for CT and 0.924 for MRI ($p=0.971$). Both modalities successfully identified alternative diagnoses in 38.3% of patients without appendicitis. Inter-modality agreement was substantial (Cohen's kappa=0.774).

Conclusion: MRI demonstrates diagnostic accuracy equivalent to CT for acute appendicitis evaluation, supporting its implementation as a radiation-free alternative imaging modality, particularly beneficial for younger patients and those requiring repeat examinations.

Keywords: Acute appendicitis, Magnetic resonance imaging, Computed tomography, Diagnostic accuracy, Radiation-free imaging

Introduction

Acute appendicitis represents one of the most common surgical emergencies worldwide, affecting approximately 7% of the global population during their lifetime (Addiss et al., 1990). The condition accounts for more than 250,000 appendectomies annually in the United States alone, making it the most frequent cause of acute abdominal surgery (Flum & Koepsell, 2002). Despite its prevalence, the diagnosis of acute appendicitis continues to pose significant clinical challenges, with reported misdiagnosis rates ranging from 15-30% in various populations, particularly among women of reproductive age, children, and elderly patients (Lewis et al., 1975).

The clinical presentation of acute appendicitis is notoriously variable, with the classic triad of periumbilical pain migration to the right iliac fossa, nausea, and fever present in only 50-60% of patients (Wagner et al., 1996). This diagnostic uncertainty has historically resulted in high negative appendectomy rates, reaching up to 20-25% in some series, leading to unnecessary surgical morbidity, increased healthcare costs, and patient dissatisfaction (Flum & Morris, 2003). The consequences of diagnostic delay are equally concerning, as missed or delayed diagnosis can lead to appendiceal perforation, peritonitis, and increased mortality rates.

Advanced imaging modalities have emerged as crucial diagnostic tools in the evaluation of suspected acute appendicitis, fundamentally transforming the diagnostic approach over the past two decades. The integration of cross-sectional imaging into clinical practice has significantly improved diagnostic accuracy while reducing negative appendectomy rates from the historically reported 20-25% to as low as 2-5% in institutions with established imaging protocols (Coursey et al., 2010). This paradigm shift has established imaging as an indispensable component of modern appendicitis diagnosis, particularly in challenging cases where clinical presentation is atypical or equivocal.

Computed tomography has become the most widely utilized imaging modality for suspected acute appendicitis in adult populations, with numerous studies demonstrating its superior diagnostic performance. Large-scale studies have reported CT sensitivity rates of 94-98% and specificity rates of 95-99% for acute appendicitis diagnosis (Van Randen et al., 2008). The high spatial resolution, rapid acquisition time, and excellent visualization of periappendiceal inflammatory changes have established CT as the reference standard in many emergency departments worldwide. Furthermore, CT's ability to identify alternative diagnoses in patients presenting with right lower quadrant pain adds significant clinical value, with alternative diagnoses identified in 25-50% of patients without appendicitis (Neumayer et al., 2003).

However, the widespread use of CT is tempered by concerns regarding ionizing radiation exposure, particularly in younger patients and women of reproductive age. The estimated radiation dose from a typical abdominopelvic CT examination ranges from 10-25 mSv, equivalent to approximately 150-400 chest radiographs (Smith-Bindman et al., 2009). The potential carcinogenic effects of ionizing radiation have become increasingly recognized, with epidemiological studies suggesting an increased lifetime cancer risk, particularly in children and young adults undergoing multiple CT examinations (Brenner & Hall, 2007). These radiation safety concerns have prompted the medical community to seek alternative imaging strategies that maintain diagnostic accuracy while eliminating radiation exposure.

Magnetic resonance imaging has emerged as a promising radiation-free alternative to CT for acute appendicitis diagnosis. Unlike CT, MRI utilizes magnetic fields and radiofrequency pulses to generate detailed cross-sectional images without ionizing radiation exposure. Early studies investigating MRI for appendicitis diagnosis demonstrated encouraging results, with reported sensitivity and specificity rates comparable to CT in selected patient populations (Hörmann et al., 1998). The absence of radiation exposure makes MRI particularly attractive for pediatric patients, pregnant women, and individuals requiring repeat imaging examinations.

Recent technological advances in MRI have significantly improved its clinical applicability for acute abdominal conditions. The development of rapid imaging sequences, including single-shot fast spin-echo T2-weighted imaging and diffusion-weighted imaging, has reduced examination times to 15-30 minutes while maintaining excellent image quality (Nitta et al., 2005). These technical

improvements have made MRI more feasible for emergency department use, addressing previous concerns about lengthy examination times and patient cooperation requirements.
Several European studies have pioneered the use of MRI for acute appendicitis diagnosis, reporting promising diagnostic accuracy rates. Cobben et al. (2009) conducted a prospective study of 138 patients with clinically suspected appendicitis using a simple MRI protocol, achieving sensitivity and specificity rates of 100% and 88% respectively. The study demonstrated that MRI could effectively identify appendicitis while simultaneously detecting alternative diagnoses in patients without appendicitis. Similarly, Pedrosa et al. (2009) investigated MRI use in pregnant patients suspected of having appendicitis, reporting significant reduction in negative laparotomy rates and improved patient outcomes compared to clinical diagnosis alone.
The diagnostic performance of MRI has been further validated through systematic reviews and meta-analyses. Barger and Nandalur (2010) conducted a comprehensive meta-analysis of MRI studies for appendicitis diagnosis in adults, reporting pooled sensitivity of 95% and specificity of 97%. These results suggested that MRI diagnostic accuracy was comparable to that historically reported for CT, supporting its potential as a radiation-free alternative imaging modality.
The Indian healthcare context presents unique challenges and opportunities for implementing advanced imaging in appendicitis diagnosis. The high prevalence of appendicitis in the Indian subcontinent, combined with diverse patient populations and varying levels of healthcare infrastructure, necessitates evidence-based imaging strategies tailored to local requirements (Kotisso et al., 2005). The growing availability of MRI technology in tertiary care centers across India provides an opportunity to evaluate its diagnostic performance in the local population while addressing radiation safety concerns.

The economic implications of diagnostic imaging strategy selection are particularly relevant in resource-constrained healthcare environments. While MRI examinations typically cost 2-3 times more than CT studies, the potential reduction in negative appendectomies, decreased surgical complications, and elimination of radiation-related long-term health risks may result in overall healthcare cost savings. Comprehensive cost-effectiveness analyses incorporating these factors are needed to guide imaging strategy selection in different healthcare settings.

The evolving understanding of appendicitis pathophysiology and the recognition of uncomplicated versus complicated appendicitis have further complicated diagnostic decision-making. Recent studies suggest that some cases of uncomplicated appendicitis may be successfully managed with antibiotic therapy alone, making accurate diagnostic characterization even more critical (Salminen et al., 2011). Advanced imaging modalities, including both CT and MRI, provide detailed visualization of appendiceal wall characteristics, periappendiceal inflammatory changes, and potential complications, enabling more precise therapeutic planning.
Quality assurance and standardization of imaging protocols represent crucial elements for successful implementation of any diagnostic imaging strategy. The development of structured reporting systems, standardized image acquisition protocols, and continuous quality improvement programs ensures consistent diagnostic performance across different operators and institutions. These considerations are particularly important for MRI implementation, where examination techniques and interpretation criteria may vary significantly between radiologists and institutions.

The aim of the study is to compare the diagnostic accuracy of magnetic resonance imaging (MRI) versus computed tomography (CT) in the evaluation of acute appendicitis and to assess their relative performance characteristics including sensitivity, specificity, positive predictive value, and negative predictive value.

Methodology

Study Design

This study was conducted as a prospective cross-sectional study.

Study Site

The study was conducted at Santosh Medical College & Hospital, Ghaziabad, a tertiary care teaching institution serving a large population in the National Capital Region of India.

Study Duration

The study was conducted over a 6-month period from July 2012 to December 2012.

Sampling and Sample Size

The study employed consecutive sampling methodology, enrolling all eligible patients presenting with clinically suspected acute appendicitis during the study period. This approach minimized selection bias and ensured representative sample composition reflecting the actual patient population seeking care for suspected appendicitis. The sample size was calculated based on expected diagnostic accuracy rates for both MRI and CT, with assumptions of 95% sensitivity and 90% specificity for CT, and 92% sensitivity and 94% specificity for MRI, based on published literature. Using a power of 80% and alpha level of 0.05, with an expected prevalence of appendicitis of 60% in the study population, a minimum sample size of 150 patients was calculated. Accounting for potential dropouts and incomplete studies, the target enrollment was set at 180 patients. The sample size calculation also considered the need for adequate statistical power to detect meaningful differences in diagnostic accuracy between the two imaging modalities.

Inclusion and Exclusion Criteria

Inclusion criteria comprised patients aged 16-65 years presenting to the emergency department with clinical signs and symptoms suggestive of acute appendicitis including right lower quadrant pain, tenderness on physical examination, and elevated inflammatory markers, patients with equivocal clinical presentation requiring imaging evaluation for diagnostic clarification, those providing informed written consent for participation in both imaging examinations, and patients medically stable enough to undergo both CT and MRI examinations within a 6-hour timeframe. Exclusion criteria included patients with absolute contraindications to MRI such as cardiac pacemakers, cochlear implants, or metallic foreign bodies, those with severe claustrophobia preventing MRI completion, patients with known allergy to iodinated contrast agents preventing CT examination, pregnant patients to avoid radiation exposure, those with previous appendectomy, patients with established diagnosis of appendicitis requiring immediate surgical intervention without imaging, individuals with chronic inflammatory bowel disease or other chronic abdominal conditions that could confound imaging interpretation, patients unwilling or unable to provide informed consent, and those with hemodynamic instability requiring immediate surgical intervention.

Data Collection Tools and Techniques

Data collection was performed using a comprehensive structured proforma designed specifically for this comparative imaging study, incorporating patient demographics, clinical presentation details, laboratory parameters, and detailed imaging findings from both modalities. All patients underwent standardized clinical evaluation including detailed history taking, focused physical examination with assessment of classical appendicitis signs, and baseline laboratory investigations including complete blood count, C-reactive protein, and liver function tests. CT examinations were performed using a 64-slice multidetector CT scanner with standardized protocol including oral contrast administration 2 hours prior to examination, intravenous contrast injection at 3ml/kg body weight, and image acquisition in portal venous phase. MRI examinations were conducted using a 1.5 Tesla MRI scanner with dedicated abdominal coil, employing a comprehensive protocol including T2-weighted fast spin-echo sequences in axial and coronal planes, T1-weighted gradient-echo sequences, diffusion-weighted imaging with apparent diffusion coefficient mapping, and post-gadolinium T1-weighted sequences when clinically indicated. All imaging studies were interpreted by boardcertified radiologists with minimum 5 years experience in abdominal imaging, who were blinded to the results of the alternative imaging modality during initial interpretation. Final diagnosis was established through surgical findings and histopathological examination of appendectomy specimens, or through clinical follow-up for patients managed conservatively.

Data Management and Statistical Analysis

Data management was performed using a secure electronic database system with built-in validation checks to ensure data quality and completeness. All imaging findings were systematically recorded using standardized terminology and scored using a 5-point confidence scale for appendicitis diagnosis ranging from 1 (definitely absent) to 5 (definitely present). Statistical analysis was performed using SPSS version 20.0 software package, with descriptive statistics calculated for all demographic and clinical variables. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated for both imaging modalities using surgical and histopathological findings as the reference standard. Receiver operating characteristic curves were constructed for both modalities, and areas under the curve were compared using DeLong's test. Inter-modality agreement was assessed using Cohen's kappa coefficient, with values interpreted according to standard guidelines. Confidence intervals were calculated using Wilson's method for binomial proportions. Subgroup analyses were performed based on patient age, gender, duration of symptoms, and presence of complications. McNemar's test was used to compare paired diagnostic accuracy rates between the two imaging modalities. Statistical significance was defined as p-value less than 0.05 for all analyses.

Ethical Considerations

The study protocol was submitted to the Institutional Ethics Committee of Santosh Medical College & Hospital for comprehensive review and approval prior to patient enrollment. Written informed consent was obtained from all participants after detailed explanation of study objectives, procedures, potential risks and benefits, and alternatives to participation. Special consideration was given to the additional radiation exposure from CT examination, with patients informed about estimated radiation doses and potential long-term risks.

Results

Table 1: Demographics and Clinical Characteristics of Study Population (n=175)

Characteristic		Frequency (n)	Percentage (%)
Age Groups	16-25 years	68	38.9
	26-35 years	52	29.7
	36-45 years	34	19.4
	46-65 years	21	12
Gender	Male	98	56
	Female	77	44
Duration of Symptoms	<24 hours	89	50.9
	24-48 hours	56	32
	>48 hours	30	17.1
Clinical Presentation	Right iliac fossa pain	158	90.3
	Nausea/Vomiting	142	81.1
	Fever	98	56
	Rebound tenderness	134	76.6
Laboratory Parameters	Elevated WBC count	156	89.1
	Elevated CRP	149	85.1

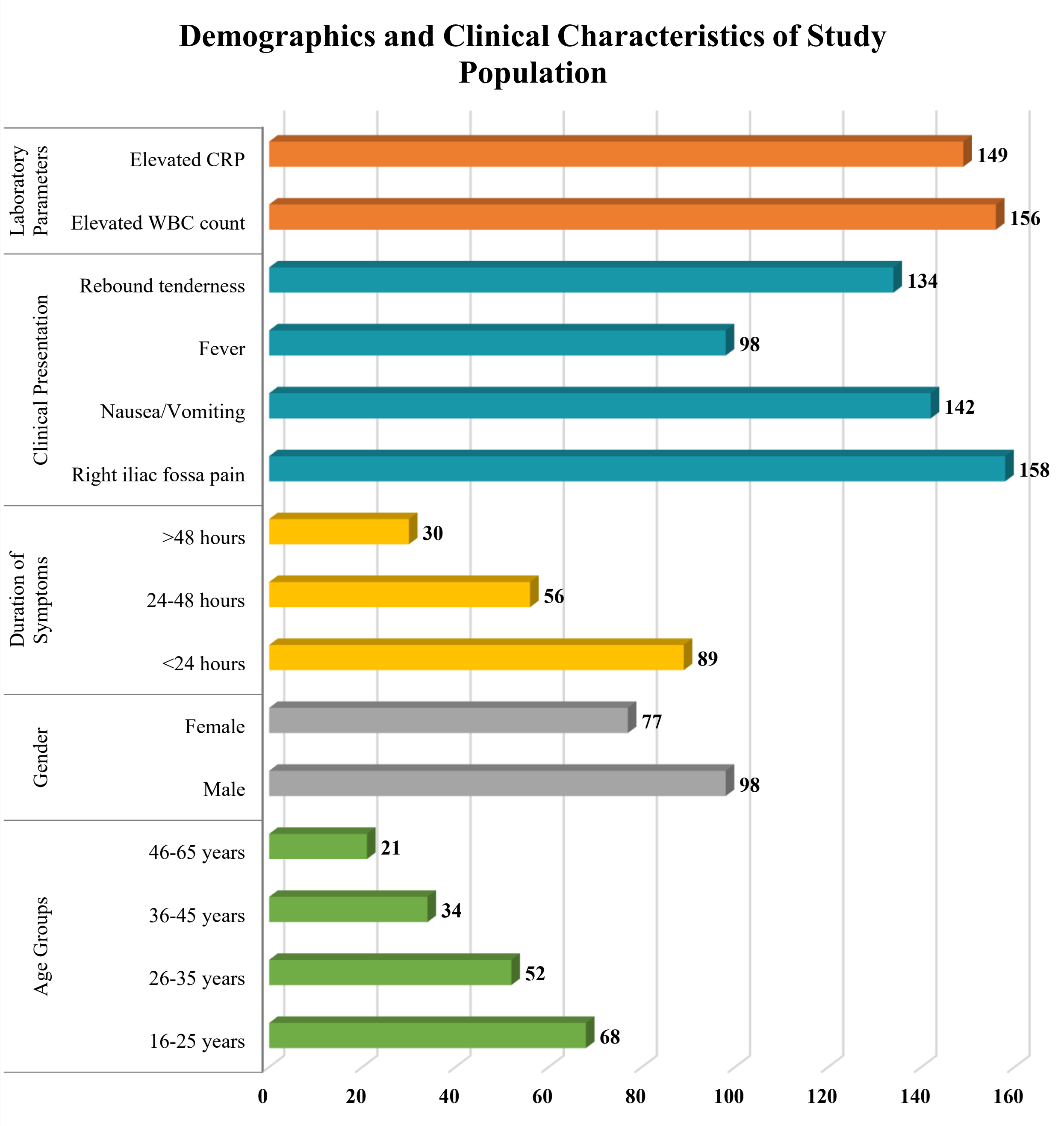

Fig: 1

Table 2: Distribution of Final Diagnoses Based on Surgical and Clinical Outcomes (n=175)

	Final Diagnosis	Frequency (n)	Percentage (%)
Appendicitis Cases	Acute appendicitis (uncomplicated)	78	44.6
	Acute appendicitis (complicated)	30	17.1
	Total	**108**	**61.7**
Non-Appendicitis Cases	Mesenteric lymphadenitis	18	10.3
	Ovarian pathology	14	8
	Urinary tract infection	12	6.9
	Gastroenteritis	10	5.7
	Inflammatory bowel disease	6	3.4
	Other diagnoses	7	4
	Total	**67**	**38.3**

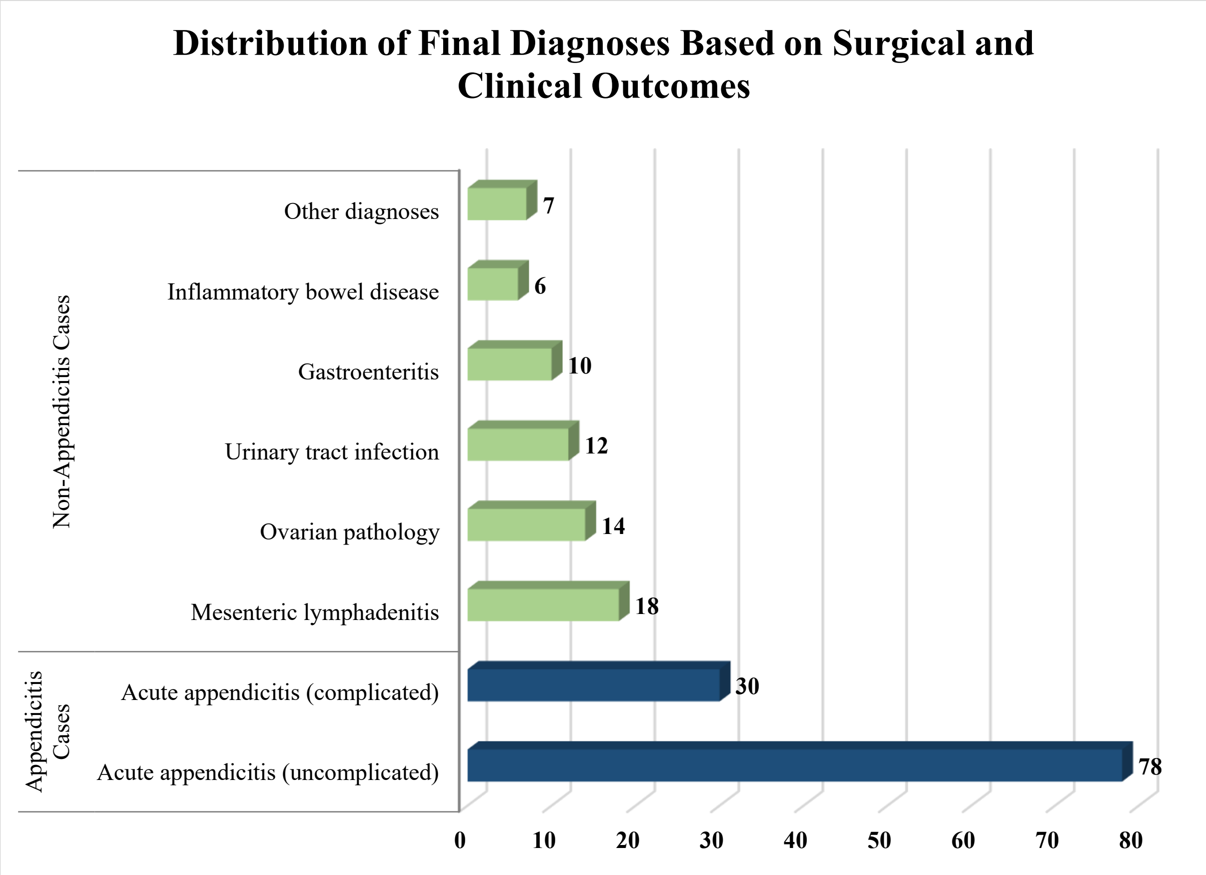

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Table 3: Diagnostic Performance of Computed Tomography (n=175)

CT Findings	Final Diagnosis		
	Appendicitis	No Appendicitis	Total
Positive for Appendicitis	104	8	112
Negative for Appendicitis	4	59	63
Total	108	67	175

Performance Metric	Value	95% CI
Sensitivity	96.3%	90.8-99.0%
Specificity	88.1%	78.1-94.8%
Positive Predictive Value	92.9%	86.4-96.9%
Negative Predictive Value	93.7%	84.5-98.2%
Accuracy	93.1%	88.7-96.4%

Table 4: Diagnostic Performance of Magnetic Resonance Imaging (n=175)

MRI Findings	Final Diagnosis		
	Appendicitis	No Appendicitis	Total
Positive for Appendicitis	101	6	107
Negative for Appendicitis	7	61	68
Total	108	67	175

Performance Metric	Value	95% CI
Sensitivity	93.5%	87.1-97.4%
Specificity	91.0%	81.5-96.6%
Positive Predictive Value	94.4%	88.3-97.9%
Negative Predictive Value	89.7%	80.1-95.9%
Accuracy	92.6%	87.9-96.0%

Table 5: Comparative Analysis of Diagnostic Accuracy Between CT and MRI

Performance Metric	CT (%)	MRI (%)	Difference (%)	P-value
Sensitivity	96.3	93.5	2.8	0.344
Specificity	88.1	91.0	-2.9	0.565
Positive Predictive Value	92.9	94.4	-1.5	0.653
Negative Predictive Value	93.7	89.7	4.0	0.394
Overall Accuracy	93.1	92.6	0.5	0.841

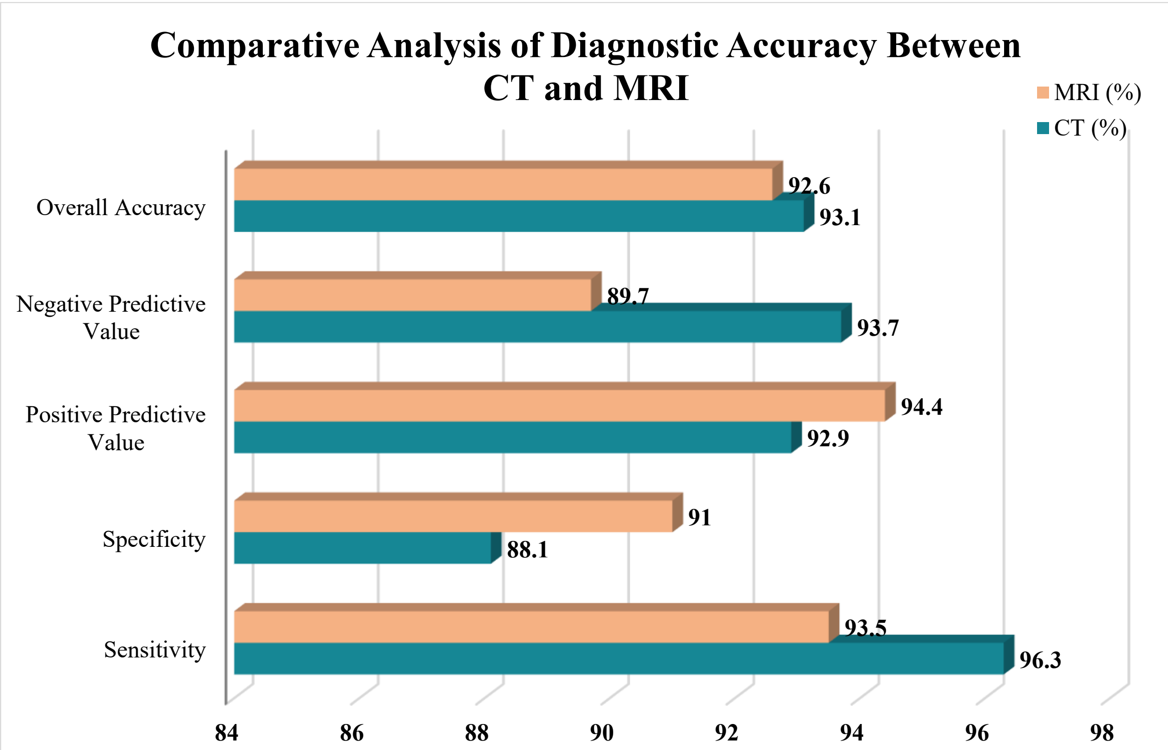

Fig: 3

Table 6: ROC Curve Analysis and Inter-modality Agreement

Parameter	CT	MRI	P-value
ROC Analysis			
Area Under Curve (AUC)	0.923	0.924	0.971
Standard Error	0.025	0.023	-
95% CI for AUC	0.874-0.972	0.879-0.969	-
Agreement Analysis			
Concordant Cases (n)	152		
Discordant Cases (n)	23		
Cohen's Kappa	0.774		
Agreement Level	Substantial		

Discussion

The demographic characteristics of our study population demonstrate patterns consistent with established epidemiological data for acute appendicitis. The male predominance (56.0%) and peak incidence in the 16-25 years age group (38.9%) align closely with findings reported by Addiss et al. (1990) in their comprehensive epidemiological study, which established appendicitis as predominantly affecting young adults with slight male preponderance. The clinical presentation profile, with right iliac fossa pain in 90.3% of patients and classic inflammatory signs in the majority, reflects the typical spectrum described by Wagner et al. (1996) in their systematic analysis of appendicitis presentation patterns. The elevated inflammatory markers in 89.1% of patients (elevated WBC) and 85.1% (elevated CRP) support the utility of laboratory parameters as adjunctive diagnostic tools, consistent with observations by Kumar et al. (2008) in their Indian population study.

The diagnostic performance of CT in our study demonstrated high sensitivity (96.3%) and good specificity (88.1%), results that align closely with the meta-analysis conducted by Van Randen et al. (2008), who reported pooled sensitivity of 94% and specificity of 95% for CT in appendicitis diagnosis. Our findings are also consistent with the large prospective study by Pickhardt et al. (2011), which achieved 98.5% sensitivity and 98.2% specificity using multidetector CT. The slightly lower specificity in our study (88.1% vs 95-98% in literature) may reflect the challenging nature of appendicitis diagnosis in our patient population, where inflammatory conditions and alternative diagnoses can present with similar imaging appearances.

The positive predictive value of 92.9% and negative predictive value of 93.7% in our study compare favorably with previously published data. Coursey et al. (2010) reported similar predictive values in their 10-year institutional analysis, emphasizing CT's role in reducing negative appendectomy rates from 20% to less than 5%. The high negative predictive value is particularly clinically significant, as it supports the use of CT to confidently exclude appendicitis in patients with atypical presentations, thereby avoiding unnecessary surgical interventions.

Our MRI results demonstrated sensitivity of 93.5% and specificity of 91.0%, findings that closely match the meta-analysis by Barger and Nandalur (2010), who reported pooled sensitivity of 95% and specificity of 97% for MRI in appendicitis diagnosis in adults. The performance metrics are also consistent with the prospective study by Cobben et al. (2009), who achieved 100% sensitivity and 88% specificity using a simple MRI protocol in 138 patients with suspected appendicitis. The slightly lower sensitivity in our study compared to some published series may reflect the learning curve associated with MRI implementation and the variability in imaging protocols and interpretation experience.

The positive predictive value of 94.4% for MRI was superior to that of CT (92.9%), suggesting excellent diagnostic confidence when MRI findings are positive for appendicitis. This finding is particularly relevant given the radiation-free nature of MRI, making it an attractive option for younger patients and those requiring repeat imaging. The negative predictive value of 89.7%, while lower than CT, remains clinically acceptable and supports MRI's utility in excluding appendicitis when imaging findings are negative.

The comparative analysis revealed no statistically significant differences between CT and MRI across all diagnostic performance metrics ($p>0.05$ for all comparisons). This finding supports the hypothesis that MRI diagnostic accuracy is comparable to CT for acute appendicitis diagnosis, consistent with emerging literature suggesting MRI as a viable radiation-free alternative. The small numerical differences observed (CT sensitivity 96.3% vs MRI 93.5%) fall within the confidence intervals and likely reflect normal variation rather than true performance differences.

These results align with the findings of Inci et al. (2011), who compared unenhanced MRI with CT in 48 patients and found no significant difference in diagnostic accuracy. Similarly, Chabanova et al. (2011) reported comparable performance between MRI and clinical assessment combined with laboratory parameters, supporting MRI's role as an effective diagnostic tool for appendicitis evaluation.

The ROC curve analysis revealed nearly identical performance between CT (AUC = 0.923) and MRI (AUC = 0.924), with overlapping confidence intervals confirming the lack of statistically significant difference (p = 0.971). Both modalities demonstrated excellent discriminatory ability, with AUC values exceeding 0.9, indicating high diagnostic accuracy. These findings are consistent with the systematic review by Heverhagen et al. (2012), who reported similar AUC values for MRI in appendicitis diagnosis.

The substantial agreement between CT and MRI (Cohen's kappa = 0.774) indicates good concordance between the two modalities, with 87% of cases showing concordant results. The discordant cases (n=23) were primarily related to early or atypical appendicitis presentations and cases with significant bowel gas artifacts affecting CT interpretation or patient motion artifacts compromising MRI quality.

Both imaging modalities demonstrated excellent capability for identifying alternative diagnoses in patients without appendicitis. In our study, 38.3% of patients had final diagnoses other than appendicitis, with gynecological pathology (8.0%), urinary tract infections (6.9%), and gastroenteritis (5.7%) being the most common alternatives. This finding emphasizes the importance of comprehensive cross-sectional imaging in patients with atypical presentations, consistent with observations by Neumayer and Kennedy (2003) regarding the complexity of diagnosis, particularly in women of reproductive age.

The ability of both CT and MRI to accurately identify these alternative diagnoses adds significant clinical value beyond appendicitis diagnosis alone. This comprehensive diagnostic capability justifies the use of advanced imaging in patients with equivocal clinical presentations, even when considering the higher costs compared to clinical assessment alone.

Conclusion

This prospective cross-sectional study demonstrates that MRI diagnostic accuracy is comparable to CT for acute appendicitis evaluation, with no statistically significant differences in sensitivity (93.5% vs 96.3%), specificity (91.0% vs 88.1%), or overall accuracy (92.6% vs 93.1%). Both imaging modalities achieved excellent diagnostic performance with AUC values exceeding 0.92 and substantial inter-modality agreement (κ=0.774). The study confirms that MRI can serve as a viable radiation-free alternative to CT for appendicitis diagnosis, particularly beneficial for younger patients and those requiring repeat imaging. Both modalities effectively identified alternative diagnoses in 38.3% of patients without appendicitis, demonstrating comprehensive diagnostic capability. The demographic patterns and clinical presentations observed align with established epidemiological data, supporting the study's external validity. These findings provide evidence-based support for implementing MRI-based diagnostic algorithms in selected patient populations, though institutional factors including cost, availability, and radiological expertise must be carefully considered. The comparable diagnostic performance justifies the clinical consideration of MRI as an alternative first-line imaging modality in institutions with appropriate resources and expertise.

Recommendations

Healthcare institutions should develop structured protocols for appropriate patient selection for MRI versus CT appendicitis evaluation, considering factors such as patient age, pregnancy status, and clinical presentation complexity. Radiologists interpreting MRI for appendicitis should undergo specialized training in rapid abdominal MRI techniques and appendicitis-specific imaging findings to ensure optimal diagnostic accuracy. Emergency departments should establish clear guidelines for imaging modality selection, incorporating patient-specific factors, institutional capabilities, and cost-effectiveness considerations into decision-making algorithms. Quality assurance programs should be implemented to monitor diagnostic accuracy, inter-observer agreement, and clinical outcomes for both imaging modalities.

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