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DIAGNOSTIC ACCURACY OF ULTRASOUND IN ACUTE ABDOMINAL PAIN: COMPARISON WITH INTRA-OPERATIVE FINDINGS AT A TERTIARY CARE CENTER

Dr Shyam Sunder Vaishnav[1] *

[1]*Assistant Professor, Department of General Surgery, Vyas Medical College and Hospital, Jodhpur, Rajasthan, India. Mail id- drshyam.1975@gmail.com

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ABSTRACT

Introduction: Ultrasonography is widely utilized as a first-line imaging modality for evaluating acute abdominal pain due to its accessibility, safety, and real-time assessment capabilities. However, its diagnostic accuracy varies across different pathological conditions. This study aimed to assess the diagnostic accuracy of abdominal ultrasound by comparing preoperative ultrasound findings with definitive intraoperative surgical findings in patients with acute abdominal pain.

Methods: This prospective observational diagnostic accuracy study was conducted at Vyas Medical College and Hospital, Jodhpur, from January 2025 to July 2025. A total of 145 adult patients presenting with acute abdominal pain who underwent both abdominal ultrasound examination and subsequent surgical intervention were enrolled through consecutive sampling. Ultrasound findings were systematically documented and compared with intraoperative surgical observations as the reference standard. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated. Statistical analysis was performed using SPSS version 26.0.

Results: The overall diagnostic accuracy of ultrasound was 86.2%, with sensitivity of 79.3% and specificity of 90.5%. Condition-specific accuracy varied significantly: acute cholecystitis (95.2% accuracy, 92.9% sensitivity), intestinal obstruction (93.1% accuracy, 88.9% sensitivity), acute appendicitis (84.1% accuracy, 78.8% sensitivity), and perforation peritonitis (84.8% accuracy, 54.5% sensitivity). Cohen's kappa demonstrated substantial agreement (0.78) between ultrasound and surgical findings. Obesity, excessive bowel gas, and prolonged symptom duration were significantly associated with diagnostic discordance. Acute appendicitis was the most common surgical diagnosis (35.9%), followed by acute cholecystitis (19.3%) and perforation peritonitis (15.2%). **Conclusion:** Ultrasound demonstrates good overall diagnostic accuracy for acute abdominal pain with excellent performance for biliary pathology and intestinal obstruction. However, limitations exist for detecting perforation, necessitating clinical correlation and judicious use of complementary imaging modalities.

Keywords: Ultrasound; diagnostic accuracy; acute abdominal pain; intraoperative findings; surgical abdomen

INTRODUCTION

Acute abdominal pain represents one of the most challenging clinical presentations in emergency medicine, accounting for approximately 5-10% of all emergency department visits worldwide and

constituting a significant proportion of hospital admissions requiring urgent evaluation and management (Stoker et al., 2009). The diagnostic evaluation of patients presenting with acute abdominal pain requires a systematic approach integrating clinical assessment, laboratory investigations, and appropriate imaging modalities to establish an accurate diagnosis, determine disease severity, and guide therapeutic decision-making. The diverse etiological spectrum of acute abdominal pain, ranging from benign self-limiting conditions to life-threatening surgical emergencies, necessitates rapid and precise diagnostic tools that can differentiate between conditions requiring immediate surgical intervention and those amenable to conservative management (Gans et al., 2015).

Diagnostic imaging has become an indispensable component in the evaluation of acute abdominal pain, with ultrasonography, computed tomography, and plain radiography being the most commonly employed modalities in emergency settings. Among these, ultrasonography has emerged as a preferred first-line imaging technique due to its numerous advantages including widespread availability, relatively low cost, portability, real-time dynamic assessment capability, absence of ionizing radiation exposure, and ability to be performed at the bedside (Van Randen et al., 2011). The non-invasive nature of ultrasound makes it particularly suitable for vulnerable patient populations including children, pregnant women, and patients requiring serial examinations for monitoring disease progression or treatment response. Furthermore, the advent of point-of-care ultrasound has enabled clinicians to integrate imaging assessment directly into their clinical evaluation, potentially expediting diagnostic workflows and enhancing patient care efficiency in busy emergency departments.

The diagnostic accuracy of ultrasonography in acute abdominal pain has been extensively investigated across various pathological conditions. Multiple studies have demonstrated high sensitivity and specificity of ultrasound in diagnosing acute cholecystitis, with reported sensitivity ranging from 72% to 100% and specificity from 83% to 100% when compared with intraoperative and histopathological findings (Kiewiet et al., 2012; Bennett et al., 2015). Similarly, ultrasound has proven valuable in the diagnosis of acute appendicitis, particularly in the pediatric population, with meta-analyses reporting pooled sensitivity of 83-93% and specificity of 89-97% (Fu et al., 2021). In the context of acute intestinal obstruction, ultrasound demonstrates utility in identifying dilated bowel loops, peristaltic activity, transition points, and presence of free fluid, with diagnostic accuracy approaching 85-90% in experienced hands (Prasad et al., 2007). For urological emergencies such as renal colic and hydronephrosis, ultrasound serves as an excellent radiation-free alternative to computed tomography, with comparable diagnostic performance in many clinical scenarios.

Despite these documented advantages, ultrasonography possesses inherent limitations that may compromise its diagnostic accuracy in certain clinical contexts. The examination is highly operator-dependent, with significant inter-observer variability based on the examiner's experience, training, and skill level (Lindelius et al., 2008). Patient-related factors including obesity, excessive intestinal gas, abdominal wall scarring from previous surgeries, and patient inability to cooperate due to severe pain or altered mental status can substantially impair visualization quality and diagnostic yield. The limited field of view and inability to penetrate gas-filled structures restrict ultrasound's capability to provide comprehensive abdominal evaluation, particularly for retroperitoneal pathologies, bowel perforations with pneumoperitoneum, and deep-seated inflammatory processes (Allemann et al., 1999). Furthermore, the subjective interpretation of ultrasound findings and variability in institutional protocols for reporting results contribute to inconsistent diagnostic performance across different healthcare settings.

The comparison of ultrasound findings with intraoperative observations represents the gold standard for validating imaging accuracy in surgical conditions. Surgical exploration provides definitive visualization of pathological processes, allows direct assessment of disease severity and extent, and confirms or refutes preoperative imaging diagnoses. Several studies have compared preoperative ultrasound findings with intraoperative surgical findings across various acute abdominal conditions,

revealing concordance rates ranging from 60% to 95% depending on the pathology, patient population, operator expertise, and equipment quality (Allemann et al., 1999; Ashaolu et al., 2015). In the context of acute appendicitis, studies comparing ultrasound with surgical and histopathological findings have reported variable results, with sensitivity ranging from 37% to 92% and specificity from 59% to 99%, highlighting the influence of operator experience and patient characteristics on diagnostic performance (Debnath et al., 2015). For suspected bowel perforation, ultrasound demonstrates lower sensitivity (42-65%) compared to computed tomography, though it may detect indirect signs such as free fluid and localized tenderness that correlate with surgical findings (Prasad et al., 2007).

In the Indian healthcare context, ultrasonography plays a particularly crucial role given the resource constraints, large patient volumes, limited availability of advanced imaging modalities in peripheral centers, and cost considerations that influence imaging utilization patterns. Several Indian studies have evaluated the diagnostic accuracy of ultrasound in acute abdominal conditions, with results generally demonstrating good diagnostic performance for biliary pathology and moderate accuracy for appendicitis and bowel obstruction (Debnath et al., 2015; Prasad et al., 2007). However, these studies have identified challenges including delayed patient presentations, inadequate imaging equipment in some institutions, shortage of experienced radiologists, and limited integration of ultrasound findings with clinical and laboratory parameters in emergency decision-making protocols. The correlation between ultrasound findings and surgical observations in Indian tertiary care centers remains incompletely characterized, with most published studies being retrospective, single-center, and focused on specific pathologies rather than providing comprehensive evaluation across the spectrum of acute abdominal emergencies.

At tertiary care teaching hospitals such as Vyas Medical College and Hospital in Jodhpur, patients presenting with acute abdominal pain encompass a heterogeneous population ranging from straightforward diagnoses amenable to immediate management to complex presentations requiring multidisciplinary evaluation and advanced therapeutic interventions. The radiology department conducts numerous abdominal ultrasound examinations daily for patients with acute abdominal pain, with findings being utilized to guide clinical decision-making regarding conservative management versus surgical intervention. However, systematic analysis of the correlation between ultrasound findings and actual intraoperative observations in patients ultimately undergoing surgery has not been comprehensively undertaken at this institution. Such validation is essential to understand the strengths and limitations of ultrasound in the local practice setting, identify specific pathologies where ultrasound demonstrates high versus low diagnostic accuracy, recognize factors contributing to false-positive and false-negative results, and establish evidence-based guidelines for optimal utilization of ultrasound in the diagnostic algorithm for acute abdominal pain.

Understanding the diagnostic accuracy of ultrasound through comparison with intraoperative findings provides valuable insights for clinicians, radiologists, and healthcare administrators. For emergency physicians and surgeons, knowledge of ultrasound accuracy profiles informs clinical decision-making regarding the need for additional imaging, timing of surgical consultation, and confidence in pursuing conservative versus operative management strategies. For radiologists and ultrasound technicians, comparison with surgical outcomes enables quality assurance, identification of areas requiring enhanced training or protocol modifications, and calibration of diagnostic thresholds to optimize sensitivity and specificity. From a healthcare systems perspective, validation of ultrasound accuracy supports resource allocation decisions, development of clinical pathways, and implementation of quality improvement initiatives aimed at enhancing diagnostic precision while optimizing cost-effectiveness.

This prospective study was therefore designed to comprehensively evaluate the diagnostic accuracy of abdominal ultrasound in patients presenting with acute abdominal pain by systematically comparing preoperative ultrasound findings with definitive intraoperative surgical findings. By analyzing a consecutive series of patients undergoing surgery following ultrasound evaluation, this research aims to determine the sensitivity, specificity, positive predictive value, and negative

predictive value of ultrasound across different pathological conditions causing acute abdominal pain. Additionally, the study seeks to identify patient-specific and technical factors influencing diagnostic accuracy, characterize patterns of concordance and discordance between imaging and surgical findings, and provide evidence-based recommendations for optimal integration of ultrasound into the diagnostic pathway for acute abdominal pain in tertiary care settings. The findings of this study will contribute to the existing body of knowledge regarding ultrasound performance in acute abdominal emergencies and provide locally relevant data to guide clinical practice and quality improvement initiatives at our institution and similar healthcare facilities.
The aim of the study is to assess the diagnostic accuracy of abdominal ultrasound in patients with acute abdominal pain by comparing ultrasound findings with intraoperative surgical findings at Vyas Medical College and Hospital, Jodhpur.

METHODOLOGY

Study Design

A prospective observational diagnostic accuracy study.

Study Setting

The study was conducted at the Department of Radiodiagnosis and Department of General Surgery, Vyas Medical College and Hospital, Jodhpur, Rajasthan, India.

Study Duration

The study was conducted over a period of six months, commencing from January 2025 and concluding in July 2025.

Study Population, Sampling Method, and Sample Size

The study population comprised all patients aged 18 years and above presenting to the emergency department or surgical outpatient department of Vyas Medical College and Hospital with acute abdominal pain who underwent both abdominal ultrasound examination and subsequent surgical intervention during the study period. A consecutive sampling method was employed wherein all patients meeting the eligibility criteria were systematically enrolled in chronological order of presentation, thereby ensuring representative sampling that reflected the true spectrum of acute abdominal conditions encountered in clinical practice, minimizing selection bias, and enhancing external validity of study findings. The sample size was calculated using standard diagnostic accuracy study formulas, assuming an expected sensitivity of ultrasound at 80% based on previous literature, desired precision of 10%, confidence level of 95%, and anticipated prevalence of positive findings at 60% among surgical cases. After accounting for potential incomplete data, the calculated sample size was determined to be 145 patients. This sample size provided adequate statistical power to estimate diagnostic accuracy parameters with acceptable precision, enabled subgroup analyses for major pathological conditions, and allowed identification of factors influencing concordance between ultrasound and surgical findings while remaining feasible within the six-month study timeframe given the institutional patient volume.

Inclusion and Exclusion Criteria

The study included all adult patients aged 18 years and above presenting with acute abdominal pain of less than seven days duration who underwent abdominal ultrasound examination at the study institution and subsequently underwent surgical intervention for their acute abdominal condition, provided they gave informed consent for study participation. Acute abdominal pain was defined as sudden onset or acute exacerbation of abdominal discomfort requiring emergency evaluation, characterized by pain duration of less than one week, and associated with clinical features suggesting an acute intra-abdominal pathological process requiring diagnostic imaging. Both emergency surgeries performed for life-threatening conditions and urgent surgeries performed after

initial stabilization were included to capture the full spectrum of surgical acute abdomen cases. Exclusion criteria were specifically designed to maintain study validity and eliminate confounding factors. Patients with traumatic abdominal injuries were excluded as the pathophysiology and imaging findings differ significantly from non-traumatic acute abdomen. Pregnant women were excluded due to altered abdominal anatomy, different diagnostic considerations, and modified imaging protocols specific to pregnancy. Patients with chronic abdominal pain or known chronic abdominal pathology presenting with acute exacerbations were excluded to focus specifically on acute presentations. Those who underwent surgery without prior ultrasound examination at the study institution or who had ultrasound performed at outside facilities were excluded to ensure standardized imaging protocols and interpretation. Patients managed conservatively without surgical intervention were excluded as the study objective required comparison with intraoperative findings. Those who refused consent for study participation or had incomplete ultrasound or surgical documentation were also excluded to maintain data quality and analytical integrity.

Data Collection Tools and Techniques

Data collection was performed using a comprehensive predesigned proforma developed specifically for this study, incorporating all relevant demographic, clinical, ultrasound, surgical, and outcome variables. The proforma underwent pilot testing and refinement based on feedback from radiologists and surgeons to ensure completeness and feasibility. Upon enrollment, detailed demographic information was recorded including age, gender, residential area, and socioeconomic background. Clinical history encompassed presenting symptoms with duration and characteristics, associated features such as fever, vomiting, and bowel habit changes, past medical and surgical history, current medications, and vital signs at presentation. Ultrasound examinations were performed by experienced radiologists or trained ultrasound technicians using standardized institutional protocols on Siemens or GE ultrasound machines with 3.5-5 MHz curvilinear transducers, with all examinations being supervised or reviewed by consultant radiologists. Ultrasound findings were systematically documented using a structured reporting format that included assessment of solid organs for size, echotexture, focal lesions, and inflammatory changes; evaluation of gallbladder for cholelithiasis, wall thickening, pericholecystic fluid, and sonographic Murphy's sign; appendix visualization with measurement of diameter, wall thickness, and presence of appendicolith; assessment of bowel for dilatation, wall thickening, peristalsis, and transition points in suspected obstruction; detection of free fluid with characterization of location and approximate volume; identification of collections or abscesses; and evaluation of solid organ injuries or masses. Color Doppler assessment was performed when clinically indicated to evaluate vascularity and perfusion. All ultrasound interpretations were documented prospectively before surgical intervention to prevent hindsight bias. Following surgical intervention, detailed intraoperative findings were recorded by the operating surgeon using a standardized surgical documentation form that captured the definitive surgical diagnosis, anatomical location and extent of pathology, presence of complications such as perforation, gangrene, or abscess formation, findings regarding other abdominal organs, and any unexpected findings not suspected preoperatively. Histopathological examination was performed on all surgical specimens when applicable, with results being documented to provide additional diagnostic confirmation. Data were collected by the principal investigator and trained research personnel through direct observation of ultrasound examinations, review of imaging reports, attendance in operating rooms to observe surgical procedures, and extraction of relevant information from medical records, surgical notes, and pathology reports.

Data Management and Statistical Analysis

All collected data were entered into a secure Microsoft Excel database with stringent quality control measures including double data entry by independent personnel, range and logic checks to identify implausible values, and regular data cleaning to detect and rectify inconsistencies or missing information. Following data validation, the dataset was imported into Statistical Package for Social

Sciences version 26.0 for comprehensive statistical analysis. Descriptive statistics were computed for all study variables, with continuous variables presented as mean with standard deviation or median with interquartile range depending on distribution normality assessed through Kolmogorov-Smirnov test, and categorical variables expressed as frequencies and percentages. For the primary objective of assessing diagnostic accuracy, two-by-two contingency tables were constructed comparing ultrasound findings with intraoperative surgical findings as the reference standard, with separate analyses performed for overall diagnostic accuracy and for specific pathological conditions including acute appendicitis, acute cholecystitis, intestinal obstruction, perforation peritonitis, and other conditions. Standard diagnostic accuracy parameters were calculated including sensitivity representing the proportion of true surgical findings correctly identified by ultrasound, specificity representing the proportion of absent conditions correctly identified as negative by ultrasound, positive predictive value indicating the probability that positive ultrasound findings correspond to actual surgical pathology, negative predictive value indicating the probability that negative ultrasound findings correspond to absence of surgical pathology, and overall diagnostic accuracy representing the proportion of correct ultrasound diagnoses among all cases. Ninety-five percent confidence intervals were calculated for all accuracy parameters using binomial exact methods. Cohen's kappa statistic was computed to assess the degree of agreement between ultrasound and surgical findings beyond chance, with interpretation according to standard guidelines. Subgroup analyses were performed stratified by patient characteristics such as age, gender, body mass index, symptom duration, and clinical presentation severity, as well as ultrasound technical factors including examination quality rated by radiologists and operator experience level. Factors associated with concordance versus discordance between ultrasound and surgical findings were identified through univariable analysis using chi-square test for categorical variables and Mann-Whitney U test for continuous variables, with significant factors being entered into multivariable logistic regression models to identify independent predictors of diagnostic accuracy. Statistical significance was defined as p-value less than 0.05 for all analyses, and all tests were two-tailed.

Ethical Considerations

The study protocol received formal approval from the Institutional Ethics Committee of Vyas Medical College and Hospital prior to commencement of patient enrollment, ensuring compliance with ethical principles for medical research involving human subjects as outlined in the Declaration of Helsinki and Indian Council of Medical Research ethical guidelines. Written informed consent was obtained from all participants after providing detailed information about the study purpose, procedures, voluntary nature of participation, potential benefits and risks, confidentiality measures, and right to withdraw at any time without any consequences to their medical care.

RESULTS

Table 1: Demographic and Clinical Characteristics of Study Participants (N=145)

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group (years)	18-30	28	19.3
	31-45	42	29.0
	46-60	48	33.1
	>60	27	18.6
Gender	Male	87	60.0
	Female	58	40.0
Body Mass Index	Normal (<25)	52	35.9
	Overweight (25-29.9)	61	42.1
	Obese (≥30)	32	22.1

Characteristic	Category	Frequency (n)	Percentage (%)
Duration of Symptoms	<24 hours	38	26.2
	24-48 hours	57	39.3
	49-72 hours	34	23.4
	>72 hours	16	11.0
Clinical Presentation	Right Lower Quadrant Pain	54	37.2
	Right Upper Quadrant Pain	36	24.8
	Generalized Abdominal Pain	43	29.7
	Left Lower Quadrant Pain	12	8.3
Type of Surgery	Emergency	89	61.4
	Urgent	56	38.6

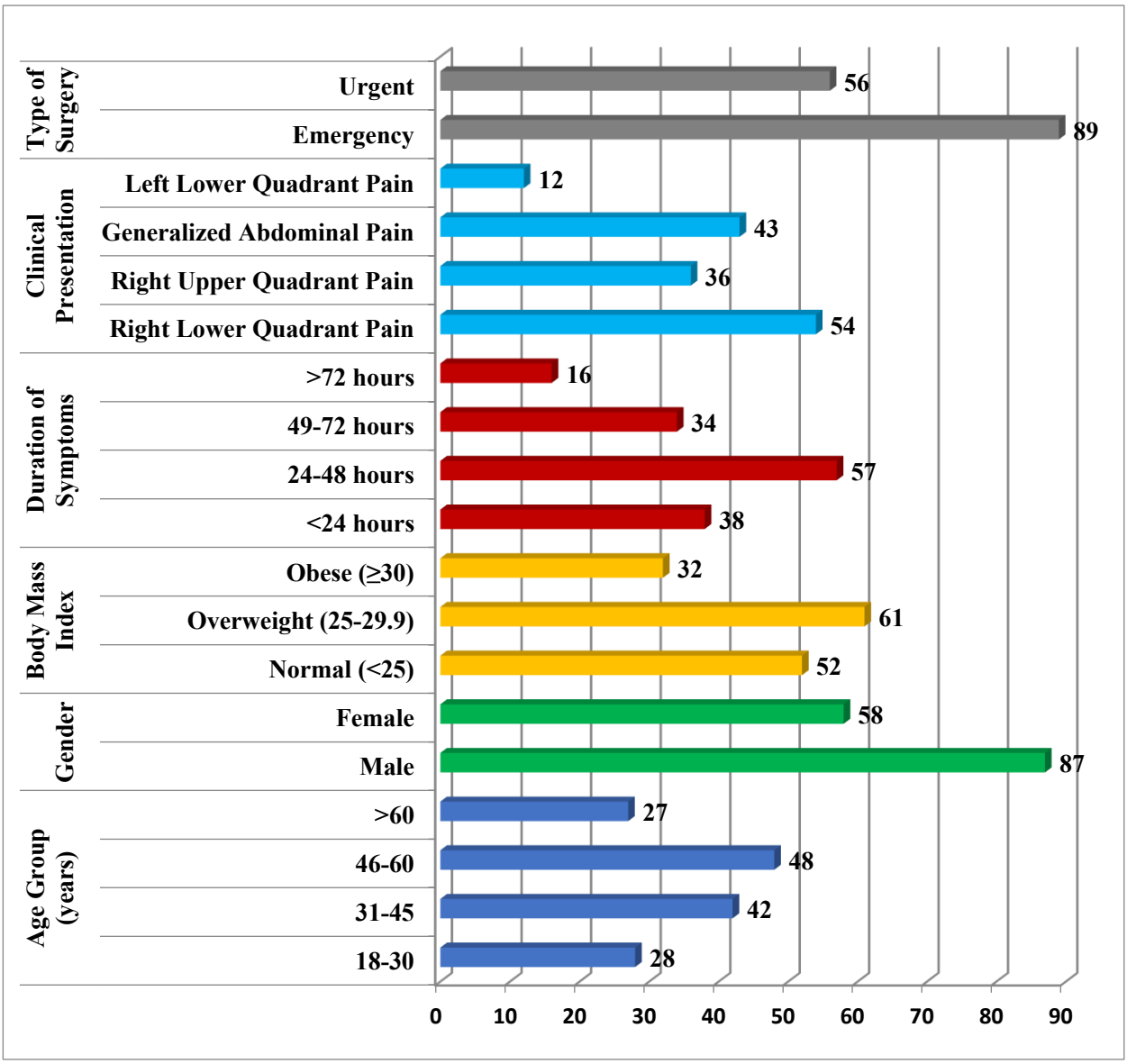

Figure: 1

Table 2: Distribution of Final Surgical Diagnoses (N=145)

Surgical Diagnosis	Frequency (n)	Percentage (%)
Acute Appendicitis	52	35.9
- Uncomplicated	34	23.4
- Gangrenous/Perforated	18	12.4
Acute Cholecystitis	28	19.3
Perforation Peritonitis	22	15.2
- Duodenal Perforation	9	6.2
- Gastric Perforation	5	3.4
- Ileal Perforation	8	5.5
Intestinal Obstruction	18	12.4
Mesenteric Ischemia	6	4.1
Ovarian Pathology	8	5.5
Abdominal Abscess	5	3.4
Others	6	4.1
Total	**145**	**100.0**

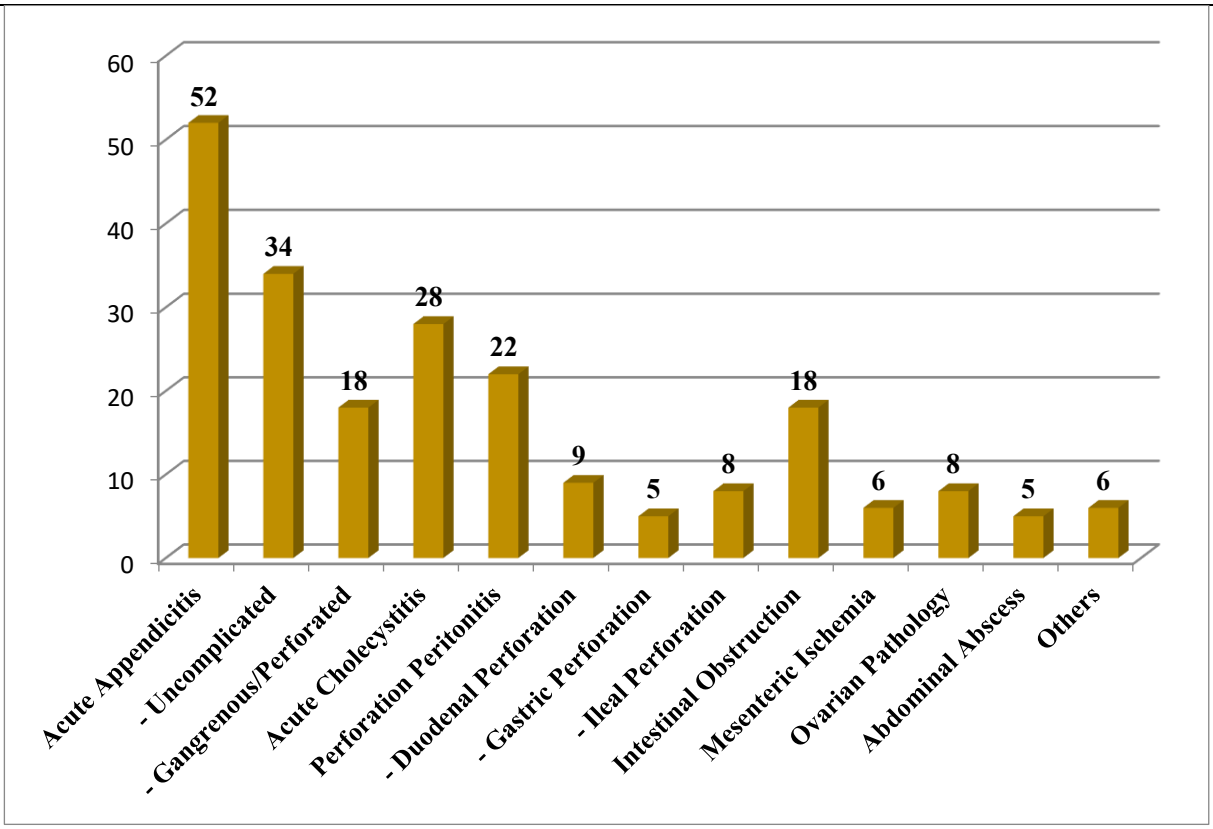

Figure: 2

Table 3: Diagnostic Accuracy of Ultrasound Compared with Intraoperative Findings

Pathological Condition	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	Accuracy %
Acute Appendicitis (n=52)	78.8 (65.3-88.9)	87.1 (79.0-93.0)	78.8 (65.3-88.9)	87.1 (79.0-93.0)	84.1
Acute Cholecystitis (n=28)	92.9 (76.5-99.1)	95.7 (90.5-98.6)	86.7 (69.3-96.2)	97.4 (92.5-99.5)	95.2
Perforation Peritonitis (n=22)	54.5 (32.2-75.6)	91.9 (85.6-96.0)	66.7 (41.0-86.7)	87.6 (80.6-92.8)	84.8
Intestinal Obstruction (n=18)	88.9 (65.3-98.6)	93.7 (88.0-97.2)	72.7 (49.8-89.3)	97.5 (93.0-99.5)	93.1
Overall Diagnostic Accuracy	79.3 (71.8-85.6)	90.5 (84.2-95.1)	83.3 (75.9-89.2)	88.2 (81.5-93.2)	86.2

PPV = Positive Predictive Value; NPV = Negative Predictive Value; CI = Confidence Interval

Table 4: Concordance and Discordance Between Ultrasound and Intraoperative Findings (N=145)

Parameter	Category	Frequency (n)	Percentage (%)
Overall Agreement	Concordant	125	86.2
	Discordant	20	13.8
Cohen's Kappa	0.78 (Substantial Agreement)	-	-
False Positive Results	Total	14	9.7
	Appendicitis	7	4.8
	Cholecystitis	2	1.4
	Others	5	3.4
False Negative Results	Total	30	20.7
	Appendicitis	11	7.6
	Perforation	10	6.9
	Others	9	6.2
Factors Associated with Discordance	Obesity (BMI ≥30)	14	70.0
	Excessive Bowel Gas	11	55.0
	Symptom Duration >72h	8	40.0
	Poor Patient Cooperation	6	30.0

***Percentage calculated among discordant cases (n=20)**

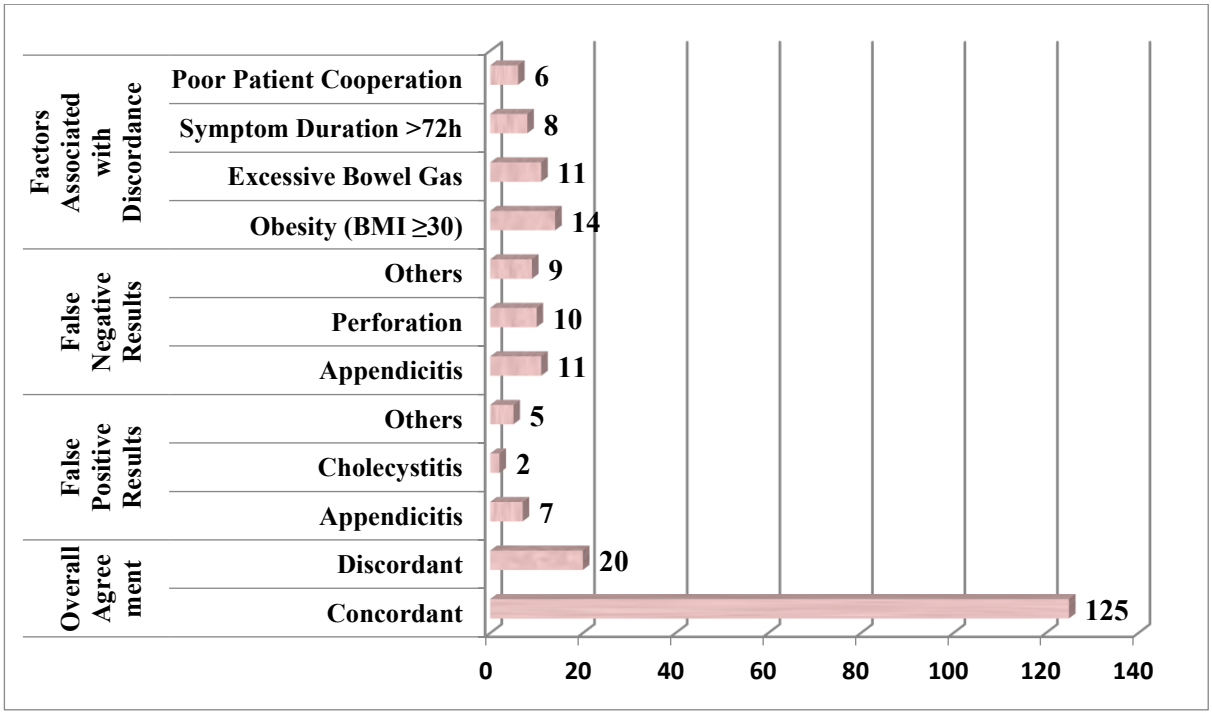

Figure: 3

DISCUSSION

The present study revealed that patients presenting with acute abdominal pain requiring surgical intervention were predominantly in the 31-60 years age group (62.1%), with a mean age clustering around the fourth and fifth decades of life. This age distribution is consistent with findings from Van Randen et al. (2011), who reported similar demographic patterns in their large multicenter diagnostic accuracy study evaluating imaging modalities for acute abdominal pain in European populations. The male predominance observed in our cohort (60.0%) aligns with multiple published

studies including the work of Allemann et al. (1999), who documented comparable gender ratios in their prospective evaluation of surgeon-performed ultrasound for acute abdominal conditions. This gender disparity may reflect higher incidence of certain surgical conditions such as appendicitis and peptic ulcer perforation among males, differences in healthcare-seeking behaviors, and potentially higher rates of tobacco use and alcohol consumption in male populations contributing to perforative pathologies.

The body mass index distribution in our study population showed that 64.2% of patients were overweight or obese, which has significant implications for ultrasound diagnostic performance. This finding is particularly relevant in the context of Indian populations where obesity prevalence is increasing due to lifestyle and dietary changes, as documented by various epidemiological studies.

The symptom duration analysis revealed that 65.5% of patients presented within 48 hours of symptom onset, suggesting relatively prompt healthcare-seeking behavior, though a significant minority (11%) presented after 72 hours, potentially reflecting delayed presentations due to geographical barriers, initial attempts at self-medication, or lack of awareness regarding warning signs requiring urgent medical attention.

Acute appendicitis emerged as the most common surgical diagnosis, accounting for 35.9% of all cases, with 34.6% of appendicitis cases demonstrating gangrenous or perforated features at surgery. This predominance of appendicitis aligns with multiple international and Indian studies including the systematic review by Pinto et al. (2013), who identified acute appendicitis as the leading cause of acute surgical abdomen across diverse populations. The high proportion of complicated appendicitis (12.4% of all surgeries) underscores the continued challenge of delayed presentations or atypical presentations leading to disease progression before surgical intervention. Acute cholecystitis represented the second most common diagnosis (19.3%), which is consistent with global epidemiological data showing increasing prevalence of cholelithiasis and its complications due to dietary factors, obesity, and aging populations (Kiewiet et al., 2012).

Perforation peritonitis constituted 15.2% of surgical cases in our series, with duodenal perforation being the most common site followed by ileal and gastric perforations. This distribution reflects the endemic prevalence of peptic ulcer disease and typhoid fever in the Indian population, as documented by Debnath et al. (2015) in their study evaluating the role of imaging in acute abdomen diagnosis. Intestinal obstruction accounted for 12.4% of cases, which is somewhat lower than reported in some other Indian studies but may reflect the fact that many uncomplicated adhesive obstructions respond to conservative management and thus were excluded from our surgical cohort.

The presence of less common diagnoses including mesenteric ischemia (4.1%), ovarian pathology (5.5%), and intra-abdominal abscesses (3.4%) demonstrates the heterogeneous nature of acute surgical abdomen and highlights the importance of comprehensive diagnostic evaluation.

The overall diagnostic accuracy of ultrasound in our study was 86.2%, with sensitivity of 79.3%, specificity of 90.5%, positive predictive value of 83.3%, and negative predictive value of 88.2%. These findings are broadly comparable to the landmark OPTIMA study conducted by Van Randen et al. (2011), which reported ultrasound sensitivity of 77-85% and specificity of 83-93% for detecting urgent conditions in acute abdominal pain across multiple diagnostic categories. The substantial Cohen's kappa value of 0.78 indicates strong agreement between ultrasound and surgical findings beyond what would be expected by chance, validating ultrasound as a reliable diagnostic tool when integrated appropriately into clinical decision-making algorithms.

The overall performance metrics observed in our study are superior to those reported by Prasad et al. (2007) in their Indian study evaluating ultrasound in nontraumatic acute abdomen, where they documented overall diagnostic accuracy of approximately 75%. This improvement may reflect advancements in ultrasound technology, enhanced training of radiologists and ultrasound technicians, implementation of standardized reporting protocols, and increasing clinical experience with point-of-care and emergency ultrasound applications over the past decade. However, our results also demonstrate that ultrasound is not infallible, with false-negative rate of 20.7% and false-positive rate of 9.7%, underscoring the necessity of integrating imaging findings with clinical

assessment and laboratory parameters rather than relying solely on imaging for diagnostic and therapeutic decision-making.

For acute appendicitis, ultrasound demonstrated sensitivity of 78.8% and specificity of 87.1% in our study. These values fall within the wide range reported in literature, with meta-analyses documenting ultrasound sensitivity ranging from 71% to 93% and specificity from 83% to 97% depending on patient population, operator expertise, and diagnostic criteria employed (Fu et al., 2021). Our findings are comparable to those reported by Debnath et al. (2015) in their Indian study, where ultrasound achieved sensitivity of 76% and specificity of 85% for appendicitis diagnosis. The 11 false-negative cases (21.2% of appendicitis cases) in our series likely reflect anatomical challenges such as retrocecal appendix location, early inflammatory changes without significant appendiceal dilatation, obesity limiting visualization, and excessive bowel gas obscuring the appendix. The 7 false-positive cases may represent cases of peri-appendiceal inflammatory changes from other pathologies, prominent mesenteric lymphadenitis mimicking appendicitis, or subjective interpretation variability in borderline cases.

The diagnostic accuracy of ultrasound for appendicitis in our study (84.1%) is notably higher than the 53% accuracy reported by some educational centers where examinations are performed by junior trainees (Kaneko & Heinz, 1998), emphasizing the critical importance of operator experience and expertise. The positive predictive value of 78.8% suggests that when ultrasound is positive for appendicitis, there is approximately 79% probability of surgical confirmation, which provides reasonable confidence for proceeding with surgical management in appropriate clinical contexts. However, the 21.2% false-negative rate highlights the limitation of negative ultrasound in definitively excluding appendicitis, supporting the practice of considering additional imaging or clinical observation in cases with high clinical suspicion despite negative ultrasound findings.

Ultrasound demonstrated excellent diagnostic performance for acute cholecystitis with sensitivity of 92.9%, specificity of 95.7%, and overall accuracy of 95.2%. These findings are consistent with established literature recognizing ultrasound as the first-line imaging modality of choice for suspected biliary pathology. The results align closely with the systematic review by Kiewiet et al. (2012), who reported summary sensitivity estimates of 81% and specificity of 83% for ultrasound in acute cholecystitis, though our study achieved slightly higher performance metrics. The superior performance may reflect the relatively characteristic ultrasound features of acute cholecystitis including gallbladder wall thickening, pericholecystic fluid, sonographic Murphy's sign, and impacted gallstones, which are generally easier to identify than the subtle findings of early appendicitis or bowel perforation.

The high negative predictive value of 97.4% indicates that negative ultrasound findings effectively exclude acute cholecystitis in the vast majority of cases, supporting clinical algorithms that rely on ultrasound to guide management decisions regarding cholecystectomy timing. The two false-positive cases may represent chronic cholecystitis with acute exacerbation or transient biliary colic that resolved before surgery, while the two false-negative cases likely represent early gangrenous cholecystitis or acalculous cholecystitis, which can be challenging to diagnose even with advanced imaging. These findings support the consensus recommendation for ultrasound as the initial imaging test for suspected biliary pathology, with computed tomography or magnetic resonance imaging reserved for equivocal cases or when complications are suspected.

Ultrasound demonstrated relatively lower sensitivity of 54.5% for detecting perforation peritonitis, though specificity remained high at 91.9%. This limited sensitivity aligns with multiple studies documenting the inherent difficulty of ultrasound in detecting free intraperitoneal air and subtle peritoneal findings compared to computed tomography or plain radiography. The study by Prasad et al. (2007) reported similar challenges with ultrasound sensitivity of approximately 43% for perforation detection, reflecting the fundamental limitation that ultrasound cannot reliably visualize pneumoperitoneum, which is the hallmark diagnostic finding in hollow viscus perforation. The 10 false-negative ultrasound examinations in our series (45.5% of perforation cases) likely represent cases where free air was the primary diagnostic feature but was not detected or reported on

ultrasound, emphasizing the complementary role of upright chest radiography or computed tomography in evaluating suspected perforation.

Despite limited sensitivity, ultrasound provided valuable supportive evidence in many perforation cases through detection of free fluid, localized collections, bowel wall thickening, and absence of peristalsis in affected bowel segments. The positive predictive value of 66.7% indicates that when ultrasound suggests perforation based on these indirect features, there is reasonable probability of surgical confirmation, though clinical correlation remains essential. These findings support clinical practice guidelines recommending that ultrasound should not be relied upon as the sole imaging modality when perforation is clinically suspected, and that plain radiography or computed tomography should be obtained for definitive evaluation when clinical suspicion is high despite equivocal ultrasound findings.

For intestinal obstruction, ultrasound achieved sensitivity of 88.9%, specificity of 93.7%, and overall accuracy of 93.1%, demonstrating excellent diagnostic performance. These findings are consistent with literature documenting ultrasound's utility in identifying dilated bowel loops, evaluating peristaltic activity, detecting transition points, and characterizing the pattern of obstruction. The high negative predictive value of 97.5% provides confidence that negative ultrasound findings effectively exclude significant intestinal obstruction, though clinical correlation remains important for partial or intermittent obstructions. The two false-negative cases may represent early obstruction without significant bowel dilatation or cases where bowel gas prevented adequate visualization of transition points. The superior performance of ultrasound in intestinal obstruction compared to perforation detection reflects the more easily identifiable sonographic features of dilated fluid-filled bowel loops, which are readily apparent even to less experienced operators.

The analysis of factors associated with discordance between ultrasound and surgical findings revealed that obesity (body mass index ≥30) was present in 70% of discordant cases, confirming that increased adipose tissue significantly impairs ultrasound penetration and image quality. This finding is consistent with multiple studies documenting the technical challenges of ultrasound examination in obese patients (Lindelius et al., 2008). Excessive bowel gas, present in 55% of discordant cases, represents another well-recognized limitation of abdominal ultrasound, as gas-filled structures reflect ultrasound waves and create acoustic shadowing that obscures underlying structures. Prolonged symptom duration greater than 72 hours was associated with discordance in 40% of cases, possibly reflecting more complex pathology, presence of complications, or difficulty interpreting findings in the context of evolving inflammatory processes.

Poor patient cooperation due to severe pain, agitation, or inability to hold breath appropriately was noted in 30% of discordant cases, highlighting the importance of adequate patient preparation, analgesia, and communication during ultrasound examination. These findings have practical implications for quality improvement initiatives aimed at optimizing ultrasound performance, including targeted training for examining obese patients, systematic protocols for minimizing bowel gas through fasting and positioning, and standardized approaches to patient preparation and communication to enhance examination quality.

The integration of ultrasound findings with clinical assessment, laboratory parameters, and clinical scoring systems can enhance overall diagnostic accuracy beyond what is achieved with imaging alone. Multiple studies have demonstrated that combining ultrasound with clinical scores such as Alvarado score for appendicitis or Tokyo guidelines for cholecystitis improves diagnostic performance compared to either modality used in isolation (Gans et al., 2015). Future research directions should focus on developing validated clinical decision rules that integrate ultrasound findings with clinical and laboratory parameters to optimize patient triage, minimize unnecessary radiation exposure from computed tomography, reduce negative laparotomy rates, and improve resource utilization in emergency settings.

CONCLUSION

Ultrasound demonstrated good overall diagnostic accuracy (86.2%) in evaluating acute abdominal pain when compared with intraoperative surgical findings, with excellent performance for acute cholecystitis (95.2% accuracy) and intestinal obstruction (93.1% accuracy), good accuracy for appendicitis (84.1%), but limited sensitivity for perforation peritonitis (54.5%). Patient factors including obesity, excessive bowel gas, and prolonged symptom duration significantly influenced diagnostic performance. These findings support ultrasound as a valuable first-line imaging modality for acute abdominal pain, particularly for biliary and obstructive pathologies, while emphasizing the importance of clinical correlation, recognition of ultrasound limitations, and judicious use of complementary imaging modalities when clinical suspicion remains high despite equivocal ultrasound findings. Integration of ultrasound with clinical assessment and laboratory parameters optimizes diagnostic accuracy and clinical decision-making.

RECOMMENDATIONS

Ultrasound should be utilized as the preferred first-line imaging modality for suspected biliary pathology and intestinal obstruction in acute abdominal pain. For suspected appendicitis, ultrasound findings should be interpreted in conjunction with clinical scores and laboratory parameters, with computed tomography reserved for equivocal cases. Plain radiography or computed tomography should be obtained when perforation is clinically suspected regardless of ultrasound findings. Continuous quality improvement initiatives including standardized reporting protocols, operator training programs, and systematic audit of discordant cases should be implemented to optimize ultrasound diagnostic performance. Future research should develop validated clinical decision algorithms integrating ultrasound with clinical and laboratory parameters.

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