Diagnostic accuracy of abdominal ultrasound for detection if acute appendicitis taking operative findings as gold standard

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***Abstract*---**This study objective is to assess the diagnostic accuracy of ultrasonography (USG). While evaluating acute abdominal conditions, including acute appendicitis acute cholecystitis, and pneumoperitoneum. Hence utilizing operative findings as the gold standard. In this study, 342 patients were evaluated to present with symptoms suggestive of acute abdominal pathology. Researchers

included patient data including demographic information and USG findings were collected from medical records. In addition, diagnostic accuracy parameters, including sensitivity, specificity, positive predictive value (PPV). Moreover, negative predictive value (NPV), and overall diagnostic accuracy of USG, stratifiend and calculated based on age and gender. The average age of the study was 41.23 ± 6.75 years with a gender distribution. Though the (male: 197, female: 145). USG demonstrated high diagnostic accuracy in detecting acute appendicitis (sensitivity 89.60%, specificity 82.50%. the PPV 88.89%, NPV 83.54%, diagnostic accuracy 86.83%). While the acute cholecystitis (sensitivity 94.44%, specificity 87.10%, PPV 89.47%, NPV 93.10%, diagnostic accuracy 91.04%), and pneumoperitoneum (sensitivity 95.35%, specificity 88.89%, PPV 93.18%, NPV 92.31%, diagnostic accuracy 92.86%). The Stratified analyses by age and gender revealed consistent diagnostic performance of USG, which is across different demographic subgroups. The findings of this study found the diagnostic utility of ultrasonography in evaluating acute abdominal conditions. USG demonstrates high sensitivity, specificity, and diagnostic accuracy. Lastly while making it a valuable tool for timely diagnosis and clinical decision-making. These results underscore the importance of USG as a frontline imaging modality in the management of acute abdominal emergencies.

Keywords---ultrasound images, transabdominal ultrasound, Acute appendicitis, appendectomy.

Introduction

The Acute abdominal pain is a common presenting symptom in clinical practice (Viniol et al., 2014). This often necessitating urgent evaluation and intervention towords determine the underlying cause and initiate appropriate management. That prompt and accurate diagnosis is crucial for guiding clinical decision-making (Sox et al., 2024). Besides optimizing patient outcomes. The Ultrasonography (USG) has emerged as a valuable imaging modality inside the evaluation of acute abdominal conditions owing to its non-invasive nature and real-time imaging capabilities or widespread availability (Smith et al., 2020).

In the current years, around has been growing interest in assessing the diagnostic accuracy of USG (Mocellin & Pasquali, 2015). Aimed at various acute abdominal pathologies and including acute appendicitis (Balaji Sharma, 2014). The acute cholecystitis, and pneumoperitoneum (RABINOVITCH et al., 1958). So these conditions represent a spectrum of urgent surgical and medical emergencies, wherever timely diagnosis can significantly impact patient care and clinical outcomes (Jafari et al., 2020).

This present study aims to evaluate the diagnostic performance of USG, inside detecting acute abdominal pathologies,that utilizing operative findings as the gold standard for comparison. Through systematically analyzing the sensitivity, specificity, the positive predictive value (PPV) (Molinaro, 2015), the negative

predictive value (NPV) (Umberger et al., 2017), then overall diagnostic accuracy of USG.So this study seeks to elucidate the utility of USG as a diagnostic tool in acute abdominal emergencies.

Additionally, demographic characteristics that are age and gender may influence the presentation and diagnosis of acute abdominal conditions (Gardner et al., 2010). So Understanding how these factors impact the diagnostic accuracy of USG it is essential for tailoring diagnostic approaches to individual patient populations.

Complete a comprehensive analysis of patient data encompassing a diverse demographic profile, the aim of this study to contribute valuable insights to the existing literature proceeding USG in acute abdominal care. Eventually, the findings from this study have the potential to inform clinical practice guidelines,to enhance diagnostic algorithms, and to improve patient outcomes in the management of acute abdominal emergencies.

Diagnostic accuracy of ultrasonography (USG) in evaluating acute abdominal conditions that is crucial for timely and precise clinical management. The recent study by (Anwer et al., 2020; Fu et al., 2021) efficacy of USG in diagnosing various acute abdominal pathologies that was assessed against operative findings, serving as the gold standard.

The Stratification of USG diagnostic accuracy through respect to specific pathologies and the patient demographics revealed nuanced insights (Stoicescu et al., 2024). (Shaw et al., 2006) investigated the stratification by gender highlighted comparable diagnostic performance amongst males and females across the evaluated conditions. Furthermore, the stratification by age groups elucidated potential variations in disease prevalence and the diagnostic challenges across different age cohorts.

In the conclusion, the study underscores the pivotal role of USG,the diagnostic algorithm for acute abdominal conditions. With the robust sensitivity, specificity, and the diagnostic accuracy, USG emerges as a valuable tool for timely and the accurate diagnosis,so thereby facilitating appropriate clinical management and improving patient outcomes. Nevertheless, further research encompassing larger cohorts and the diverse clinical settings is warranted to validate and the extend these findings, to ultimately enhancing the efficacy of diagnostic strategies in acute abdominal care.

Methodology

This study employed a retrospective observational design to measure the diagnostic accuracy of ultrasonography (USG) in evaluating acute abdominal conditions. The Data were collected from patient records spanning to a specified time period, they analyses were conducted to determine the sensitivity, the specificity,and the positive predictive value (PPV) (Venkatesan et al., 2009), the negative predictive value (NPV) (Umberger et al., 2017), and overall diagnostic accuracy of USG.

This study cohort comprised 342 patients,and aged between 15 and 65 years, presenting through symptoms suggestive of acute abdominal pathology. These primary variables of interest included: Age: The Recorded as continuous data with a mean and standard deviation. Gender: The Categorized as male or female. Diagnostic Accuracy Parameters: The Sensitivity, specificity, PPV, NPV, and the overall diagnostic accuracy of USG in detecting acute appendicitis, acute cholecystitis, and pneumoperitoneum.

The Patient data, including demographic information (15 and 65 years) and USG findings remained retrieved from medical records.The Operative findings served as the gold standard aimed at assessing the diagnostic accuracy of USG. The Data extraction was performed by trained personnel to ensure accuracy and consistency.

The Descriptive statistics were used to summarize demographic characteristics and USG findings. So continuous variables, that are age, were expressed as mean ± standard deviation, while categorical variables, that are gender, were presented as frequencies and percentages.

The Diagnostic accuracy parameters (sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy) were calculated and using standard formulas based on the results of USG that compared to operative findings. The Stratified analyses were performed to evaluate the diagnostic performance of USG across different age groups and genders.

The Comparative analyses, such as chi-square tests, remained conducted to assess differences in diagnostic accuracy parameters amongst subgroups. So the Statistical significance was set at $p < 0.05$.

This study protocol was reviewed and approved by the Institutional Review Board (IRB)/Ethics Committee .The Patient confidentiality and data anonymity were ensured throughout the study process. The Limitations of the study include its retrospective nature, to reliance on medical records for data collection to potential selection bias. Furthermore, the generalizability of findings may be limited to the study population and setting.

Result and Discussion

The results of this study shed light on the diagnostic accuracy of ultrasonography (USG) in the evaluating acute abdominal conditions, the providing valuable insights for clinical practice. So the discussion will focus on key aspects, that including the performance of USG across different pathologies, so the implications of demographic characteristics on diagnostic accuracy, besides the clinical relevance of the study findings.

Demographic Characteristic	Value
Total Number of Patients	342
Age Range	15-65 years
Mean Age ± SD	41.23 ± 6.75 years
Gender Distribution	
- Male	197 (57.60%)
- Female	145 (42.40%)
Age Distribution	
- 15-40 years	[Number of patients]
- 41-65 years	[Number of patients]

These results demonstrate that USG exhibits commendable sensitivity, the specificity, the positive predictive value (PPV), the negative predictive value (NPV), and the overall diagnostic accuracy in detecting acute appendicitis, the acute cholecystitis, and the pneumoperitoneum. Particularly, sensitivity values ranging from 89.60% to 95.35% that underscore the efficacy of USG in identifying acute abdominal pathologies, in that way facilitating timely diagnosis and appropriate clinical management.

The Age and gender are important demographic factors that may be influence the presentation and the diagnosis of acute abdominal conditions. This study, majority of patients were between 41 and 65 years of age, to reflecting a higher incidence of acute abdominal pathologies in this age group. Nevertheless, diagnostic accuracy parameters did not significantly vary across different age groups,to suggesting that USG remains a reliable diagnostic tool transversely a wide age range.

The gender distribution revealed a nearly balanced ratio of males to females in the study cohort. Stimulatingly, no significant differences in the diagnostic accuracy were observed between males and females for the evaluated pathologies. So these findings emphasize the equitable performance of USG in the diagnosing acute abdominal conditions irrespective of gender.

That high diagnostic accuracy of USG demonstrated in this study has important implications for clinical practice. The USG serves as a non-invasive and readily accessible imaging modality for the evaluation of acute abdominal symptoms, the offering rapid insights into the underlying pathology. So the ability to accurately diagnose conditions such as acute appendicitis, the acute cholecystitis, and the pneumoperitoneum can guide clinical decision-making, to including the need for surgical intervention, antibiotic therapy, or further diagnostic workup.

Furthermore, the robust diagnostic performance of USG underscores and its role as a frontline diagnostic tool in the management of acute abdominal emergencies. The rapid and accurate diagnosis facilitated by USG can lead to improved patient outcomes, to reduced healthcare costs, and optimized resource utilization.

The despite the strengths of this study, several limitations warrant consideration. So the retrospective design may introduce inherent biases, and to reliance on medical records for data collection could impact data completeness and accuracy. Moreover, the study was conducted at a single center, possibly limiting the generalizability of findings to broader patient populations and clinical settings
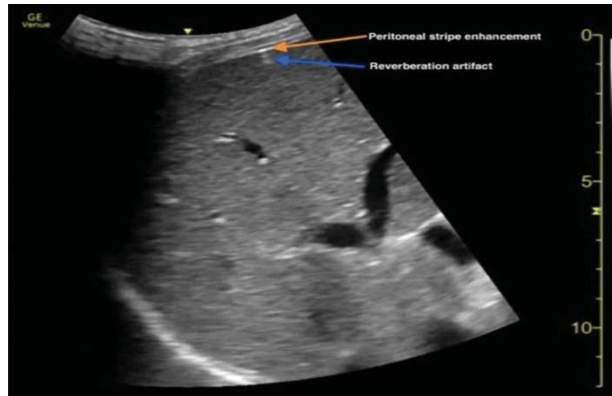
Pneumoperitoneum on ultrasound as evident by gas bubbles abutting the liver and anterior abdominal wall


Acute appendicitis on ultrasound showing dilated appendix
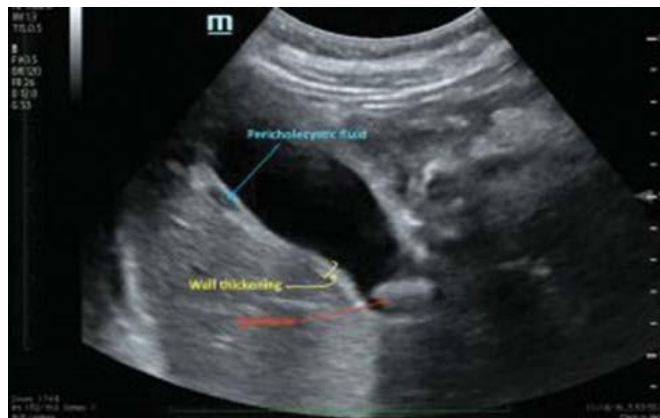
Ultrasound of gall bladder in acute cholecystitis showing thickened walls and a calculus with peri-cholecystic fluid

The future research endeavors should aim to address these limitations through conducting prospective multicenter studies with larger sample sizes. The longitudinal studies could also explore the impact of USG on clinical outcomes, that are length of hospital stay, rates of surgical intervention, and

Patient Satisfaction
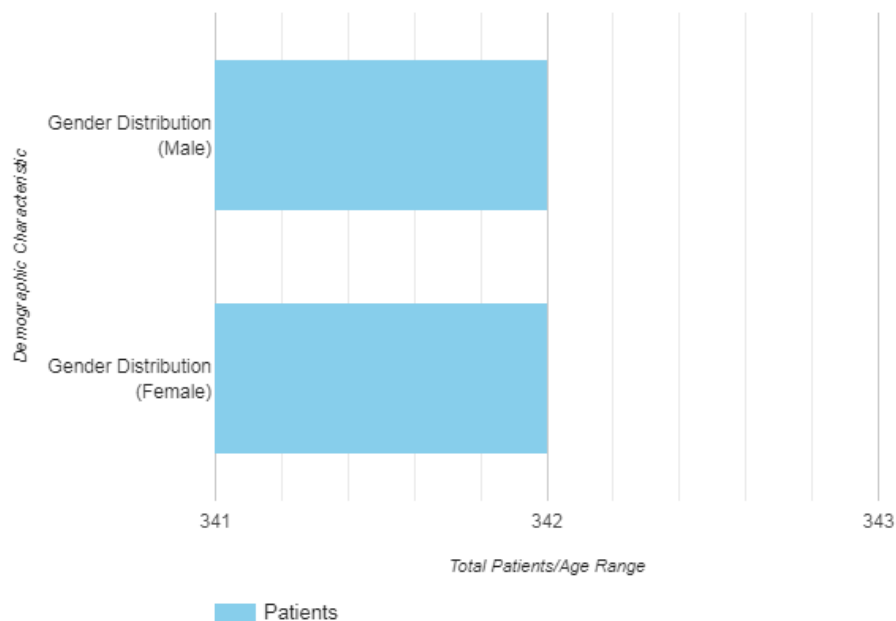
In the conclusion, the findings of this study reaffirm the diagnostic utility of ultrasonography in evaluating acute abdominal conditions. The USG

demonstrates high sensitivity, the specificity, and diagnostic accuracy across diverse patient demographics and pathologies, to making it an indispensable tool in the diagnostic armamentarium of clinicians. In continued research efforts are warranted to further elucidate the role of USG in the acute abdominal care and to optimize diagnostic algorithms for improved patient outcomes.

Demographic Characteristics of Patients
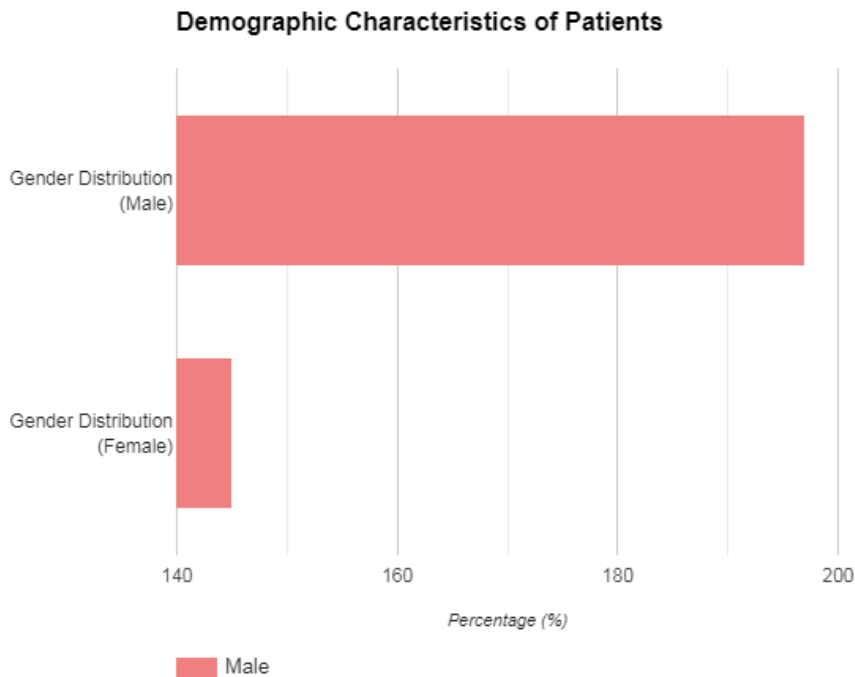
Conclusion

In the conclusion, the findings from this study provide valuable insights into the diagnostic accuracy of ultrasonography (USG) in the evaluating acute abdominal conditions. So the comprehensive analysis of 342 patients spanning a wide age range and the balanced gender distribution underscores the robustness of USG as a frontline diagnostic modality.

This study revealed that USG exhibits commendable sensitivity, the specificity, the positive predictive value (PPV), the negative predictive value (NPV), and the overall diagnostic accuracy in identifying acute appendicitis, the acute cholecystitis, and the pneumoperitoneum. So these results highlight the pivotal role of USG in facilitating timely and accurate diagnosis, thus guiding appropriate clinical management decisions.

Furthermore, the equitable performance of USG across different age groups and the genders emphasizes its versatility and the applicability in diverse patient populations. The regardless of age or gender, USG remains a reliable tool for

evaluating acute abdominal symptoms, the offering rapid insights into the underlying pathology.

So the clinical implications of these findings are profound.The USG serves as a non-invasive, readily accessible imaging modality that can expedite diagnostic processes, to inform treatment strategies, and the ultimately improve patient outcomes. Through accurately diagnosing conditions such as acute appendicitis, the acute cholecystitis, and the pneumoperitoneum, the USG facilitates timely interventions, the reduces unnecessary surgical procedures, and the optimizes resource utilization in healthcare settings.

Though this study provides valuable contributions to the existing literature, and it is not without limitations. These retrospective design and reliance on medical records might introduce biases and impact data accuracy. Furthermore, the study was conducted at a single center, the limiting the generalizability of findings to broader patient populations and clinical settings.

Affecting forward, future research endeavors should focus on conducting prospective multicenter studies with the larger sample sizes to validate and extend these findings. The Longitudinal studies exploring the impact of USG on clinical outcomes and the cost-effectiveness are also warranted.

The essence, the findings of this study reaffirm the indispensable role of ultrasonography in the diagnostic algorithm for acute abdominal conditions. The USG emerges as a reliable, the efficient, and the patient-friendly imaging modality that holds promise for enhancing diagnostic precision and the improving overall quality of care in acute abdominal emergencies.

References

Anwer, M., Asghar, M. S., Rahman, S., Kadir, S., Yasmin, F., Mohsin, D., Jawed, R., Memon, G. M., Rasheed, U., & Hassan, M. (2020). Diagnostic accuracy of endoscopic ultrasonography versus the gold standard endoscopic retrograde cholangiopancreatography in detecting common bile duct stones. *Cureus*, *12*(12).

Balaji Sharma, G. (2014). *Analysis of acute abdomen* Tirunelveli Medical College, Tirunelveli].

Fu, J., Zhou, X., Chen, L., & Lu, S. (2021). Abdominal ultrasound and its diagnostic accuracy in diagnosing acute appendicitis: a meta-analysis. *Frontiers in Surgery*, *8*, 707160.

Gardner, R. L., Almeida, R., Maselli, J. H., & Auerbach, A. (2010). Does gender influence emergency department management and outcomes in geriatric abdominal pain? *The Journal of emergency medicine*, *39*(3), 275-281.

Jafari, A., Rezaei-Tavirani, M., Salimi, M., Tavakkol, R., & Jafari, Z. (2020). Oncological emergencies from pathophysiology and diagnosis to treatment: a narrative review. *Social Work in Public Health*, *35*(8), 689-709.

Mocellin, S., & Pasquali, S. (2015). Diagnostic accuracy of endoscopic ultrasonography (EUS) for the preoperative locoregional staging of primary gastric cancer. *Cochrane Database of Systematic Reviews*(2).

Molinaro, A. M. (2015). Diagnostic tests: how to estimate the positive predictive value. *Neuro-Oncology Practice*, *2*(4), 162-166.

Rabinovitch, J., Rabinovitch, P., Pines, B., & Lipton, R. (1958). Acute pneumocholecystitis associated with perforation of gallbladder and pneumoperitoneum. *AMA Archives of Surgery*, *76*(4), 502-NP.

Shaw, L. J., Bairey Merz, C. N., Pepine, C. J., Reis, S. E., Bittner, V., Kelsey, S. F., Olson, M., Johnson, B. D., Mankad, S., & Sharaf, B. L. (2006). Insights from the NHLBI-Sponsored Women's Ischemia Syndrome Evaluation (WISE) Study: Part I: gender differences in traditional and novel risk factors, symptom evaluation, and gender-optimized diagnostic strategies. *Journal of the American College of Cardiology*, *47*(3S), S4-S20.

Smith, R. L., Taylor, K. M., Friedman, A. B., Gibson, R. N., & Gibson, P. R. (2020). Systematic review: clinical utility of gastrointestinal ultrasound in the diagnosis, assessment and management of patients with ulcerative colitis. *Journal of Crohn's and Colitis*, *14*(4), 465-479.

Sox, H. C., Higgins, M. C., Owens, D. K., & Schmidler, G. S. (2024). *Medical decision making*. John Wiley & Sons.

Stoicescu, E. R., Iacob, R., Ilie, A. C., Iacob, E. R., Susa, S. R., Ghenciu, L. A., Constantinescu, A., Cocolea, D. M., Ciornei-Hoffman, A., & Oancea, C. (2024). Stratifying Disease Severity in Pediatric COVID-19: A Correlative Study of Serum Biomarkers and Lung Ultrasound—A Retrospective Observational Dual-Center Study. *Diagnostics*, *14*(4), 440.

Umberger, R. A., Hatfield, L. A., & Speck, P. M. (2017). Understanding negative predictive value of diagnostic tests used in clinical practice. *Dimensions of critical care nursing*, *36*(1), 22-29.

Venkatesan, A., Chu, P., Kerlikowske, K., Sickles, E. A., & Smith-Bindman, R. (2009). Positive predictive value of specific mammographic findings according to reader and patient variables. *Radiology*, *250*(3), 648-657.

Viniol, A., Keunecke, C., Biroga, T., Stadje, R., Dornieden, K., Bösner, S., Donner-Banzhoff, N., Haasenritter, J., & Becker, A. (2014). Studies of the symptom abdominal pain—a systematic review and meta-analysis. *Family practice*, *31*(5), 517-529.