

Evaluating the Efficacy of Plain Radiography and Ultrasound in the Diagnosis of Acute Abdominal Conditions in Emergency Settings

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Abstract:

Background: The acute abdomen represents a significant diagnostic challenge in emergency medicine, necessitating rapid, accurate assessment to guide management and treatment decisions. Plain radiography (X-ray) and ultrasonography (USG) are pivotal imaging modalities employed in the emergency department (ED) to diagnose various acute abdominal conditions. Their utility, however, varies based on diagnostic accuracy, application suitability, and patient-specific factors.

Objective: The review aimed to evaluate and compare the diagnostic accuracy and utility of plain X-ray and USG in the emergency management of acute abdomen, focusing on their advantages, limitations, and integration with clinical assessments.

Review Summary: Employing a structured methodology, the review meticulously analyzed peer-reviewed articles, guidelines, and expert opinions published between 2015 and 2024. The findings highlighted the situational preferences for each modality, underscoring X-ray's efficiency in identifying conditions like bowel obstruction and perforated viscus, and USG's superiority in diagnosing soft tissue abnormalities without radiation exposure. The review emphasized the importance of integrating these imaging techniques with clinical evaluation and other diagnostic methods for optimal patient care.

Future Implications: The insights garnered from this review suggest a need for ongoing research into advanced imaging technologies and diagnostic strategies that enhance accuracy and patient safety in the ED. Future studies should focus on the development of protocols that leverage the strengths of both X-ray and USG, potentially incorporating artificial intelligence to aid in interpretation and diagnosis.

Clinical Policy and Development: Based on the review's findings, clinical policies should advocate for the judicious use of X-ray and USG in diagnosing acute abdomen, tailored to the patient's specific clinical presentation and risk factors. Development of comprehensive training programs for emergency medicine practitioners on the effective use of these modalities can further improve diagnostic outcomes.

Keywords: Acute Abdomen, Emergency Department, Plain Radiography, Ultrasonography.

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Introduction

The term "acute abdomen" denotes any sudden, severe abdominal pain that necessitates immediate medical attention, potentially requiring surgical intervention. It is a clinical syndrome that can be caused by a multitude of conditions ranging from benign and self-limiting to life-threatening emergencies. The acute abdomen stands as a critical challenge in emergency medicine, embodying a wide spectrum of diseases including appendicitis, perforated peptic ulcer, and ectopic pregnancy, among others [1]. The urgency and complexity of these conditions underscore the acute abdomen's significance as a medical emergency, where timely diagnosis and management can significantly influence patient outcomes.

The Emergency Department (ED) is the frontline in the diagnosis and management of acute abdomen cases. However, diagnosing acute abdominal conditions in the ED is fraught with challenges. The clinical presentation of abdominal emergencies can be nonspecific and varied, complicating the diagnostic process. Patients of different ages, genders, and medical histories may present with similar symptoms, obscuring the underlying cause of the acute abdomen [2]. Furthermore, the high-pressure environment of the ED, coupled with the need for rapid decision-making, often with limited information, adds to the diagnostic challenges.

In the context of these challenges, rapid and accurate imaging modalities play a pivotal role in the management of acute abdomen. Plain

radiography (X-ray) and ultrasonography (USG) are two of the most commonly used imaging techniques in the ED. They are instrumental in the initial evaluation and management of patients presenting with acute abdominal conditions. Plain X-rays can quickly identify signs of perforation, obstruction, or ileus, providing crucial information with minimal patient preparation. Ultrasound, on the other hand, offers a non-invasive, bedside option for evaluating organ-specific pathology, such as gallstones or an ectopic pregnancy, without the risks associated with ionizing radiation. The choice between these imaging modalities depends on the clinical scenario, patient characteristics, and available resources, but their role in facilitating a rapid and accurate diagnosis is undisputed.

The aim of the review is to comprehensively evaluate and compare the diagnostic accuracy, utility, and situational preferences of plain radiography (X-ray) and ultrasonography (USG) in the management of patients presenting with acute abdomen in the emergency department. This review seeks to elucidate the specific advantages and limitations of each imaging modality, their applications in diagnosing various acute abdominal conditions, and how they can be effectively integrated with clinical assessment and other diagnostic tools to optimize patient care. Through a detailed examination of recent literature, guidelines, and expert opinions, the review intends to provide evidence-based insights that can guide emergency medicine practitioners in selecting the most appropriate imaging strategy for patients with acute abdominal symptoms, ultimately aiming to improve diagnostic accuracy and patient outcomes in this critical care setting.

Methodology

To undertake a comprehensive narrative review focusing on the utilization of plain X-ray and USG in diagnosing acute abdomen within the emergency department, a structured methodology was meticulously followed. The literature search strategy was designed to encompass a broad spectrum of relevant sources. Medical and scientific databases such as PubMed, MEDLINE, Cochrane Library, and Google Scholar were systematically searched using a combination of keywords related to acute abdomen diagnostics, including terms like "emergency department," "plain X-ray," "radiography," "ultrasonography," and "diagnostic accuracy." The inclusion criteria were set to consider peer-reviewed articles, guidelines, and review articles published between 2015 and 2024, available in English, and focusing specifically on the emergency department application of X-ray and USG for acute abdomen cases. Conversely, articles not directly related to the emergency department setting, case reports, and

non-English literature were excluded to maintain the review's focus and relevance.

For data extraction, a standardized form was utilized to systematically collect information on the diagnostic accuracy, advantages, limitations, and specific applications of plain X-ray and USG. This process also gathered insights on situational preferences and how these imaging techniques were integrated with other diagnostic methods.

The synthesis of findings was conducted narratively, emphasizing the comparative analysis of plain X-ray and USG in the emergency diagnosis of acute abdomen. This synthesis aimed to draw meaningful conclusions on the roles of these modalities, considering their integration with clinical practice for optimal patient management. The discussion interpreted these findings within the context of current emergency medicine practices, addressing the review's limitations and suggesting directions for future research. This methodology promised a thorough investigation into the diagnostic approaches to acute abdomen in the emergency department, offering valuable insights for practitioners in the field.

Discussion

Diagnostic Imaging Options for Acute Abdomen: The diagnostic imaging landscape for acute abdomen is diverse, offering multiple modalities tailored to the specific needs and conditions of patients. Among these, plain radiography (X-ray), ultrasonography (USG), computed tomography (CT), and magnetic resonance imaging (MRI) stand out as primary options, each with distinct advantages and applications. X-rays, often the first line of imaging, are favored for their quick turnaround, wide availability, and cost-effectiveness, proving particularly adept at identifying issues like free air from perforations, bowel obstructions, and the presence of foreign bodies.

USG, on the other hand, is celebrated for its non-invasive nature, absence of ionizing radiation, and capability for real-time imaging, making it the go-to for diagnosing conditions such as gallbladder disease, kidney stones, and issues within the female pelvis [3]. CT scans are invaluable for their comprehensive view of abdominal structures, offering high-resolution images that are crucial in diagnosing a broad spectrum of acute conditions, including intra-abdominal abscesses, complicated diverticulitis, and appendicitis with remarkable accuracy.

MRI, though less commonly utilized in urgent settings due to its longer scan times and higher costs, is unparalleled in providing excellent soft-tissue contrast without the use of ionizing radiation, making it particularly beneficial for pediatric

patients and pregnant women in assessing conditions like appendicitis and gynecological emergencies [4].

The prioritization of plain X-rays and USG over CT and MRI in the emergency department is informed by several critical factors, including speed, accessibility, safety, and diagnostic efficacy. The ability of X-rays and USG to deliver quick results is paramount in emergency situations where timely decision-making can significantly impact patient outcomes. Their widespread availability ensures that evaluations can be conducted promptly, minimizing delays in diagnosis and treatment.

Furthermore, USG is particularly favored for its safety profile, as it does not involve ionizing radiation, making it an ideal choice for assessing vulnerable groups such as pregnant women and children. Although X-rays do utilize radiation, the exposure levels are considerably lower than those associated with CT scans, thereby reducing potential risks [5]. In terms of diagnostic accuracy, both X-rays and USG have proven to be highly effective for specific conditions.

Ultrasonography is recognized as the diagnostic gold standard for cholecystitis, and plain radiography is adept at identifying bowel obstructions and perforations. This combination of speed, accessibility, safety, and efficacy underscores the rationale for the prevalent use of X-rays and USG in the fast-paced, high-stakes environment of the emergency department.

Role of Plain X-Ray in Acute Abdomen: Plain radiography, or X-ray, has long been a cornerstone in the initial assessment of patients presenting with acute abdominal conditions. Its primary indications include the evaluation of suspected bowel obstruction, perforated viscus, and the presence of certain foreign bodies. X-rays are particularly valued for their ability to rapidly identify free air under the diaphragm, indicative of gastrointestinal perforation, and to delineate air-fluid levels in cases of bowel obstruction. However, the limitations of plain X-rays are notable; they are less sensitive in detecting early-stage intra-abdominal inflammation, such as that seen in early appendicitis or mild diverticulitis, and they provide limited information on soft tissue structures [6].

Plain X-rays hold significant diagnostic value in the evaluation of specific conditions within the acute abdomen spectrum, notably in cases of bowel obstruction and perforated viscus. In instances of bowel obstruction, plain radiographs are instrumental in identifying key features such as dilated bowel loops and air-fluid levels, which are indicative of the obstruction's presence. The distribution pattern of air within the bowel loops can further assist clinicians in distinguishing

between small and large bowel obstructions, thereby informing subsequent diagnostic and therapeutic interventions [7]. Similarly, the detection of free intraperitoneal air on plain radiographs serves as a hallmark sign of a perforated viscus. This finding is crucial for prompt diagnosis, and even minimal quantities of air can be detected, especially when imaging is performed with the patient in an erect posture or using a horizontal beam lateral decubitus view in situations where standing poses a challenge [6]. These diagnostic capabilities underscore the indispensable role of plain X-rays in managing acute abdominal emergencies, providing essential information that guides the clinical approach to these potentially life-threatening conditions.

Interpreting plain X-rays in the context of acute abdomen can be challenging due to the variability in presentations and the potential for overlapping findings with other conditions. For instance, gas patterns may be nonspecific, and certain pathological conditions might not always manifest with expected radiographic findings. Moreover, the presence of previous surgical interventions, such as clips or foreign materials, can complicate the interpretation of radiographs.

The importance of correlating radiographic findings with clinical presentation cannot be overstated. A comprehensive approach that integrates the patient's history, physical examination, and laboratory results with the imaging findings is essential for accurate diagnosis. This multidisciplinary approach enhances the diagnostic utility of plain X-rays and helps mitigate their inherent limitations.

Role of Ultrasound in Acute Abdomen: Ultrasound (USG) has emerged as a pivotal imaging modality in the evaluation of patients presenting with acute abdominal conditions, offering a unique combination of advantages and specific applications while also presenting certain limitations.

The primary advantages of ultrasound include its non-invasiveness, absence of ionizing radiation, and bedside availability, making it an ideal first-line imaging tool in many clinical scenarios. Its non-invasive nature allows for repeated examinations without any adverse effects, providing a dynamic assessment of the abdominal organs. The lack of ionizing radiation is a critical benefit, particularly for vulnerable populations such as pregnant women and pediatric patients, ensuring safety across all patient groups. Furthermore, the capability for bedside imaging is invaluable in critically ill or unstable patients who cannot be easily transported to radiology suites, facilitating immediate diagnostic insights [8].

Ultrasound has established itself as a highly effective diagnostic tool for a range of conditions that present with acute abdominal symptoms, leveraging its capabilities to provide rapid, accurate diagnoses in various clinical scenarios. For instance, in the diagnosis of acute cholecystitis, ultrasound is considered the gold standard, demonstrating high sensitivity and specificity in detecting gallstones and the thickening of the gallbladder wall, which are critical indicators of the condition. This makes it an invaluable tool in both diagnosing the disease and guiding subsequent management strategies [9].

Similarly, ultrasound plays a pivotal role in identifying appendicitis, capable of visualizing an enlarged appendix, the presence of peri-appendiceal fluid, and increased blood flow through Doppler imaging. Its non-invasive nature and lack of ionizing radiation make it especially beneficial for children and pregnant women, for whom radiation exposure is a significant concern [10].

Additionally, in the realm of obstetrics, ultrasound proves indispensable for the early diagnosis of ectopic pregnancies. By allowing the visualization of the gestational sac and its location, ultrasound aids in the timely and appropriate management of this potentially life-threatening condition, underscoring its critical role in emergency gynecological care [11]. Through these applications, ultrasound demonstrates its essential role in the rapid and effective diagnosis of various acute abdominal conditions, highlighting its importance in emergency and critical care settings.

Despite its advantages, ultrasound's effectiveness is limited by several factors, including patient body habitus and bowel gas, which can obscure clear visualization of abdominal structures. Additionally, its accuracy and diagnostic yield are highly operator-dependent, requiring a significant level of skill and experience to interpret the images correctly. This variability can lead to inconsistencies in diagnostic accuracy, particularly in less common or more complex presentations of acute abdomen [7].

Comparative Analysis: Plain X-rays vs. Ultrasound in Acute Abdomen Diagnosis: The diagnostic accuracy and utility of plain X-rays and USG in the evaluation of acute abdomen vary significantly across different clinical scenarios, with each modality presenting unique advantages and limitations. This comparative analysis explores their relative effectiveness, situational preferences based on clinical presentations and patient factors, and their integration with clinical assessment and other diagnostic modalities.

Plain X-rays are highly valued for their ability to rapidly identify certain conditions, such as bowel

obstruction and perforated viscus, by visualizing air patterns and foreign bodies. However, their utility is limited in detecting soft tissue abnormalities and early stages of intra-abdominal inflammation [12]. On the other hand, USG excels in soft tissue visualization, offering superior diagnostic accuracy for conditions like cholecystitis, appendicitis, and ectopic pregnancy without the risks associated with ionizing radiation. Ultrasound's real-time imaging capability also allows for the assessment of blood flow and the differentiation of fluid from solid masses [13].

The choice between plain X-rays and USG often depends on the clinical presentation and specific patient factors. For instance, in cases of suspected bowel obstruction or perforation, plain X-rays are typically the first-line imaging due to their efficiency in detecting air-fluid levels and free air. In contrast, USG is preferred in scenarios requiring detailed evaluation of soft tissue structures, such as in suspected cholecystitis, appendicitis, or in pregnant patients where radiation exposure is a concern. Patient body habitus and the presence of bowel gas can also influence the selection of imaging modality, as these factors may limit the diagnostic effectiveness of USG [6].

The integration of imaging findings with clinical assessment and other diagnostic modalities is crucial for a comprehensive evaluation of the acute abdomen. Neither plain X-rays nor USG can independently provide definitive diagnoses in all cases. For example, the combination of clinical examination, laboratory tests, and imaging findings from both X-rays and USG can significantly enhance the diagnostic accuracy for conditions like appendicitis or intestinal obstruction. Furthermore, in complex cases where initial imaging is inconclusive, additional modalities such as CT or MRI may be warranted to obtain a definitive diagnosis [7].

Conclusion

The acute abdomen presents a significant challenge in emergency medicine, requiring swift and precise diagnostic approaches to guide treatment decisions. This review underscores the essential roles of plain radiography and ultrasonography in evaluating acute abdominal conditions within the emergency department. X-rays are crucial for quickly detecting signs of bowel obstruction and perforated viscus, whereas USG is superior for identifying soft tissue issues like cholecystitis, appendicitis, and ectopic pregnancy, all without the risks of ionizing radiation. The selection between these modalities depends on the patient's clinical presentation and specific needs, emphasizing the importance of integrating imaging results with clinical assessments and other diagnostic tools for a holistic approach. Despite their limitations, such as X-ray's

reduced sensitivity to inflammation and USG's operator dependency, both imaging techniques are invaluable, their judicious use informed by clinical insights and patient factors significantly enhances diagnostic accuracy and patient care in acute abdominal emergencies.

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References

1. Cartwright SL, Knudson MP. Evaluation of acute abdominal pain in adults. *American family physician*. 2008 Apr 1;77(7):971-8.
2. Marx J, Hockberger R, Walls R. *Rosen's Emergency Medicine-Concepts and Clinical Practice E-Book: 2-Volume Set*. Elsevier Health Sciences; 2013 Aug 1.
3. Moris D, Paulson EK, Pappas TN. Diagnosis and management of acute appendicitis in adults: a review. *Jama*. 2021 Dec 14;326(22):2299-311.
4. Zanolletti M, Coppa A, Nazerian P, Grifoni S, Scorpiniti M, Innocenti F, Conti A, Bigiarini S, Gualtieri S, Casula C, Ticali PF. Chest abdominal-focused assessment sonography for trauma during the primary survey in the emergency department: the CA-FAST protocol. *European Journal of Trauma and Emergency Surgery*. 2018 Dec; 44:805-10.
5. Arruzza E, Milanese S, Li LS, Dizon J. Diagnostic accuracy of computed tomography and ultrasound for the diagnosis of acute appendicitis: A systematic review and meta-analysis. *Radiography*. 2022 Nov 1;28(4):1127-41.
6. Gans SL, Pols MA, Stoker J, Boermeester MA, Expert Steering Group. Guideline for the diagnostic pathway in patients with acute abdominal pain. *Digestive surgery*. 2015 Mar 1; 32(1):23-31.
7. Bower KL, Lollar DI, Williams SL, Adkins FC, Luyimbazi DT, Bower CE. Small bowel obstruction. *Surgical Clinics*. 2018 Oct 1;98(5):945-71.
8. Blaser AR, Starkopf J, Malbrain ML. Abdominal signs and symptoms in intensive care patients. *Anaesthesiology intensive therapy*. 2015;47(4):379-87.
9. Oppenheimer DC, Rubens DJ. Sonography of acute cholecystitis and its mimics. *Radiologic Clinics*. 2019 May 1;57(3):535-48.
10. Shen G, Wang J, Fei F, Mao M, Mei Z. Bedside ultrasonography for acute appendicitis: An updated diagnostic meta-analysis. *International Journal of Surgery*. 2019 Oct 1; 70:1-9.
11. Scibetta EW, Han CS. Ultrasound in early pregnancy: viability, unknown locations, and ectopic pregnancies. *Obstetrics and Gynecology Clinics*. 2019 Dec 1;46(4):783-95.
12. Borofsky S, Taffel M, Khati N, Zeman R, Hill M. The emergency room diagnosis of gastrointestinal tract perforation: the role of CT. *Emergency Radiology*. 2015 Jun; 22:315-27.
13. Kameda T, Taniguchi N. Overview of point-of-care abdominal ultrasound in emergency and critical care. *Journal of Intensive Care*. 2016 Dec;4(1):1-9.