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The Role of Ultrasound in the Diagnosis and Management of Pediatric Abdominal Emergencies in Jakarta, Indonesia

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A B S T R A C T

Introduction: Pediatric abdominal emergencies demand swift and accurate diagnosis for optimal management. In resource-constrained settings, point-of-care ultrasound (POCUS) has emerged as a valuable tool. This study aimed to evaluate the utility of ultrasound in diagnosing and managing pediatric abdominal emergencies in Jakarta, Indonesia. **Methods:** A retrospective review of pediatric patients (age ≤ 18 years) presenting with acute abdominal pain to a tertiary care hospital in Jakarta from 2018 to 2023 was conducted. Data collected included demographics, clinical presentation, ultrasound findings, final diagnosis, and management decisions. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ultrasound for various abdominal emergencies were calculated. **Results:** A total of 543 patients met the inclusion criteria. The most common diagnoses were appendicitis (n=187, 34.4%), intussusception (n=82, 15.1%), and gastroenteritis (n=75, 13.8%). Ultrasound demonstrated high sensitivity and specificity for diagnosing appendicitis (92% and 88%, respectively), intussusception (95% and 90%), and free fluid in the abdomen (98% and 94%). POCUS influenced management decisions in 68% of cases, including expediting surgery or avoiding unnecessary interventions. **Conclusion:** Ultrasound is a valuable tool for the diagnosis and management of pediatric abdominal emergencies in Jakarta. Its high sensitivity and specificity, coupled with its point-of-care availability, make it particularly useful in resource-limited settings.

1. Introduction

Pediatric abdominal emergencies constitute a significant proportion of presentations to emergency departments globally, representing a diverse and challenging spectrum of conditions. The accurate and timely diagnosis of these emergencies is paramount, as delays or misinterpretations can have dire consequences, ranging from unnecessary interventions to life-threatening complications. Children, with their unique physiological and anatomical characteristics, pose specific challenges in the diagnostic process. Their ability to articulate symptoms might be limited, and the clinical presentation of various abdominal conditions can often overlap, leading to diagnostic dilemmas.[1,2]

Conventionally, the evaluation of pediatric abdominal pain has relied on a combination of clinical assessment, laboratory investigations, and imaging modalities. Clinical assessment involves a detailed history and physical examination, focusing on the onset, duration, location, and character of pain, as well as associated symptoms such as vomiting, fever, and changes in bowel habits. Laboratory tests, including complete blood count, inflammatory markers, and liver function tests, provide additional clues to the underlying etiology. Imaging modalities play a crucial role in confirming or excluding specific diagnoses. Plain radiographs, although readily available and relatively inexpensive, have limited sensitivity and specificity for many abdominal

conditions. Computed tomography (CT), with its superior spatial resolution and ability to visualize multiple organ systems, offers greater diagnostic accuracy. However, its use in children is often restricted due to concerns about radiation exposure and the potential for long-term health risks. Moreover, CT scans may necessitate sedation or anesthesia, further complicating the diagnostic process.[3,4]

In recent years, point-of-care ultrasound (POCUS) has emerged as a promising alternative to traditional imaging modalities in the evaluation of pediatric abdominal emergencies. POCUS refers to the use of ultrasound imaging by clinicians at the bedside or point of care, enabling real-time visualization of internal organs and structures. The advent of portable, high-resolution ultrasound machines has facilitated the widespread adoption of POCUS across various clinical settings, including emergency departments, critical care units, and even pre-hospital environments. POCUS offers several advantages over traditional imaging modalities in the context of pediatric abdominal emergencies. First and foremost, it eliminates the need for ionizing radiation, thereby minimizing the risk of long-term health complications associated with repeated CT scans. Second, POCUS is portable and can be readily performed at the bedside, obviating the need for patient transport and potential delays in diagnosis and treatment. Third, POCUS provides real-time imaging capabilities, allowing clinicians to dynamically assess organ motion, blood flow, and the presence of free fluid. Fourth, POCUS is relatively inexpensive and does not require specialized facilities or personnel, making it particularly attractive in resource-constrained settings.[5,6]

The applications of POCUS in pediatric abdominal emergencies are vast and continue to expand. POCUS has shown high sensitivity and specificity in detecting appendicitis, often obviating the need for CT scans. The visualization of a non-compressible, dilated appendix with a thickened wall is considered a hallmark of appendicitis on ultrasound. This condition, characterized by the telescoping of one segment of the intestine into another, is a common cause of bowel obstruction in infants and young children. POCUS can readily identify the characteristic "target sign" or "doughnut sign" associated with intussusception. POCUS can aid in the diagnosis of bowel obstruction by demonstrating dilated bowel loops, air-fluid levels, and decreased or absent peristalsis. The presence of free fluid in the abdomen, suggestive of hemorrhage or peritonitis, can be easily detected using POCUS. POCUS has also been used to diagnose various other abdominal conditions, including cholecystitis, pancreatitis, hydronephrosis, and ovarian torsion.[7,8]

Jakarta, the capital city of Indonesia, is a rapidly growing metropolis with a burgeoning population, including a significant proportion of children. The burden of pediatric abdominal emergencies in Jakarta is substantial, with a high incidence of conditions such as appendicitis, intussusception, and gastroenteritis. Access to healthcare resources, including advanced imaging modalities, remains a challenge, particularly in underserved areas. This disparity underscores the need for cost-effective, readily available diagnostic tools that can be deployed at the point of care.[9,10] The present study aimed to investigate the role of ultrasound in the diagnosis and management of pediatric abdominal emergencies in Jakarta, Indonesia.

2. Methods

This investigation employed a retrospective study design, meticulously analyzing data collected from a tertiary care hospital situated in Jakarta, Indonesia. This medical institution serves as a pivotal referral center for pediatric patients across the region, boasting a specialized pediatric emergency department and a radiology department equipped with state-of-the-art ultrasound facilities. The retrospective nature of this study was chosen due to its ability to efficiently examine pre-existing data, allowing for a comprehensive assessment of ultrasound's role in pediatric abdominal emergencies within a real-world clinical setting.

The study population encompassed all pediatric patients, defined as individuals aged 18 years or younger, who presented to the emergency department with acute abdominal pain during the period spanning from January 2018 to December 2023. This broad

timeframe enabled the capture of a substantial sample size, thereby enhancing the statistical power of the analysis. Stringent inclusion and exclusion criteria were implemented to ensure the integrity and validity of the data. Patients were included if they fulfilled the following conditions; Age: 18 years or younger at the time of presentation; Presenting complaint: Acute abdominal pain; Ultrasound examination: Underwent an abdominal ultrasound examination as part of their diagnostic workup. Conversely, patients were excluded if they met any of the following criteria; Prior abdominal surgery: A history of previous abdominal surgery could confound the interpretation of ultrasound findings; Incomplete medical records: Cases with missing or inadequate documentation were excluded to maintain data quality; Alternative imaging modalities: Patients who underwent imaging modalities other than ultrasound (e.g., CT, MRI) were not included to ensure a focused assessment of ultrasound's diagnostic role.

A systematic and comprehensive data collection process was undertaken, leveraging the hospital's electronic medical records (EMRs). Trained research personnel meticulously extracted pertinent information from the EMRs, adhering to a standardized data collection protocol. This protocol ensured consistency and minimized the risk of errors or omissions during data abstraction. The following data elements were collected for each patient; Demographics: Age, sex; Clinical presentation: Duration and location of abdominal pain, associated symptoms (e.g., vomiting, fever, diarrhea, changes in bowel habits); Ultrasound findings: Detailed description of ultrasound findings, including organ visualization, presence of pathology (e.g., appendicitis, intussusception, free fluid), and any technical limitations encountered during the examination; Final diagnosis: The definitive diagnosis established based on a combination of clinical, laboratory, and imaging findings. In select cases, surgical or pathological confirmation was used to ascertain the final diagnosis; Management decisions: The course of action taken following the ultrasound examination, including observation, medical treatment, or surgical intervention.

All ultrasound examinations were conducted by experienced radiologists or sonographers possessing specialized training in pediatric abdominal imaging. Standardized protocols were employed to ensure consistency and optimize image quality. Patients were typically positioned supine with the abdomen exposed. In some cases, alternative positions (e.g., decubitus, upright) were utilized to enhance visualization of specific structures or pathology. High-frequency linear transducers (typically 5-12 MHz) were employed to achieve optimal resolution for superficial structures. Lower frequency curvilinear transducers (2-5 MHz) were used to visualize deeper structures or in patients with larger body habitus. A systematic approach was adopted, encompassing all quadrants of the abdomen and pelvis. Specific attention was devoted to key anatomical landmarks and potential areas of pathology. Color Doppler and spectral Doppler imaging were utilized to assess blood flow and vascularity. Representative images and video clips were captured and stored in the patient's EMR for subsequent review and interpretation. Rigorous quality assurance measures were implemented throughout the data collection and analysis process. A random sample of patient records was independently reviewed by a second researcher to assess inter-rater reliability and identify any discrepancies. Data validation procedures were also performed to ensure accuracy and completeness of the dataset.

Descriptive statistics were employed to summarize patient characteristics, ultrasound findings, and management decisions. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as means and standard deviations or medians and interquartile ranges, depending on the distribution of the data. The diagnostic accuracy of ultrasound for various abdominal emergencies was evaluated using the final diagnosis as the gold standard. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each condition. These metrics provide valuable insights into the ability of ultrasound to correctly identify or exclude specific diagnoses. The impact of ultrasound on management decisions was assessed by comparing the pre- and

post-ultrasound management plans. McNemar's test was used to determine the statistical significance of any changes in management. Additionally, logistic regression analysis was performed to identify factors associated with changes in management following the ultrasound examination. All statistical analyses were conducted using SPSS version 25 (IBM Corp., Armonk, NY). A p-value of less than 0.05 was considered statistically significant.

This study was conducted in compliance with the principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of the participating hospital. As this was a retrospective study utilizing anonymized data, the need for individual patient consent was waived. Patient confidentiality was maintained throughout the research process. The datasets generated and analyzed during the current study are not publicly available due to patient confidentiality concerns. However, de-identified data may be available from the corresponding author upon reasonable request and subject to institutional approval.

3. Results and Discussion

Table 1 presents the patient characteristics in this study. The study included a total of 543 pediatric patients who presented with acute abdominal pain. The average age of these patients was 8.2 years, with the youngest being 1 and the oldest being 18, indicating a wide age range in the study population. The gender distribution was fairly balanced, with 52.3% males and 47.7% females. As expected, abdominal pain was the universal presenting symptom, affecting 100% of the patients. This aligns with the inclusion criteria of the study, which focused on children presenting with acute abdominal pain. Vomiting was the second most common symptom, reported by 62.1% of the patients. This suggests a significant association between abdominal pain and gastrointestinal upset in this cohort. Fever was present in nearly half of the patients (48.4%), indicating the potential for infectious or inflammatory processes contributing to abdominal pain. Diarrhea affected 31.3% of the patients, further supporting the possibility of gastrointestinal infections or inflammatory bowel diseases. The remaining symptoms, including constipation, lethargy, abdominal distension, and others, were less frequent but still noteworthy, contributing to the overall clinical picture of these patients.

Table 1. Patient characteristics.

Characteristic	Value
Total patients	543
Mean age (years)	8.2 (range 1-18)
Male (%)	52.30%
Female (%)	47.70%
Presenting symptoms	
Abdominal pain (%)	100%
Vomiting (%)	62.10%
Fever (%)	48.40%
Diarrhea (%)	31.30%
Constipation (%)	7%
Lethargy (%)	5%
Abdominal distension (%)	4%
Others (%)	9.60%

Table 2 provides insights into the ultrasound findings and diagnoses in this study. The table reveals that appendicitis was the most prevalent diagnosis, accounting for 34.4% of the cases. This is followed by intussusception (15.1%) and gastroenteritis (13.8%). Other common diagnoses included constipation, urinary tract infection, and mesenteric lymphadenitis. The 'Others' category, encompassing a range of less frequent diagnoses, collectively represented a significant proportion of cases (18.4%). This highlights the diversity of abdominal conditions encountered in the pediatric emergency setting. For appendicitis, ultrasound exhibited high sensitivity (92%) and specificity (88%). This suggests that ultrasound is a reliable tool for both detecting appendicitis when it is present and ruling it out when it is absent. Similarly, for intussusception, ultrasound demonstrated excellent sensitivity (95%) and specificity (90%), further emphasizing its diagnostic value in this condition. The presence of free fluid in the abdomen was also accurately detected by ultrasound, with a sensitivity of 98% and specificity of 94%. The PPV and NPV for free fluid ranged from 85% to 97%, indicating a high degree of confidence in both positive and negative ultrasound findings.

Table 2. Ultrasound findings and diagnoses.

Diagnosis	**Number of cases (n)**	**Percentage (%)**	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**
Appendicitis	187	34.40%	92%	88%	-	-
Intussusception	82	15.10%	95%	90%	-	-
Gastroenteritis	75	13.80%	-	-	-	-
Constipation	45	8.30%	-	-	-	-
Urinary tract infection	32	5.90%	-	-	-	-
Mesenteric lymphadenitis	22	4.10%	-	-	-	-
Free fluid in the abdomen	-	-	98%	94%	85-97%	85-97%
Others	100	18.40%	-	-	-	-

Table 3 presents the impact of POCUS (Point-of-Care Ultrasound) on management decisions in the context of pediatric abdominal emergencies. Table 3 succinctly highlights the significant role that POCUS played in shaping the clinical management of the pediatric patients in this study. This indicates that in nearly two-thirds of the patients, the information obtained from the bedside ultrasound examination directly contributed to the decision-making process regarding their care. This could involve confirming or ruling out a suspected diagnosis, guiding the selection of further investigations, or influencing the choice between conservative management and surgical intervention. This figure underscores the tangible impact of POCUS on patient care. In almost one-third of the cases, the ultrasound findings were pivotal enough to warrant a modification of the original treatment plan. This could involve expediting surgery for a patient with a confirmed diagnosis of appendicitis, avoiding unnecessary appendectomy in a child with mesenteric adenitis, or initiating specific medical therapy based on the visualization of free fluid or an inflamed organ.

Table 3. Impact of POCUS on management.

Impact	Percentage of cases (%)
POCUS influenced management decisions	68
POCUS led to a change in the initial management	32

In the realm of pediatric abdominal emergencies, swift and precise diagnosis is of paramount importance. This study's findings serve as a clarion call for the widespread integration of point-of-care ultrasound (POCUS) into the routine evaluation of children presenting with acute abdominal pain, particularly in resource-constrained settings like Jakarta, Indonesia. Our observations echo the chorus of mounting evidence that underscores the invaluable role of ultrasound in this crucial domain. The high sensitivity and specificity demonstrated by ultrasound in diagnosing common abdominal emergencies such as appendicitis, intussusception, and free fluid, coupled with its profound influence on management decisions, paints a compelling picture of its clinical relevance and potential to elevate the standard of care for young patients. One of the most striking revelations of this study is the exceptional diagnostic accuracy exhibited by ultrasound in identifying key abdominal pathologies. Appendicitis, a frequent surgical emergency in children, often presents with a constellation of non-specific symptoms that can confound even the most seasoned clinician. The ability of ultrasound to visualize the appendix in real-time and detect telltale signs of inflammation, such as a non-compressible, dilated appendix with a thickened wall, serves as a beacon in the diagnostic fog. This visual confirmation can expedite surgical intervention, potentially averting complications such as perforation and peritonitis. Similarly, intussusception, a condition where one segment of the intestine telescopes into another, poses a significant threat to young children. Prompt diagnosis is critical, as delays can lead to bowel ischemia and necrosis. Ultrasound's capacity to readily identify the characteristic “target sign” or “doughnut sign” associated with intussusception empowers clinicians to make swift and decisive therapeutic decisions. The detection of free fluid in the abdomen, a harbinger of potentially serious conditions like hemorrhage or peritonitis, is yet another domain where ultrasound shines. The ability to rapidly identify and quantify free fluid at the bedside can guide the need for further investigations, such as CT scans, or prompt surgical exploration, thereby optimizing patient management. Beyond its diagnostic prowess, ultrasound's influence extends to the realm of clinical decision-making. Our study revealed that POCUS played a pivotal role in shaping management strategies in a substantial proportion of cases. In nearly two-thirds of the patients, ultrasound findings directly informed the course of action, underscoring its transformative potential in the clinical workflow. In some instances, ultrasound findings prompted a shift from a conservative approach to surgical intervention, ensuring timely treatment for conditions like appendicitis or bowel obstruction. In other cases, ultrasound helped avert unnecessary surgeries, sparing children from the risks and burdens associated with invasive procedures. For example, a child presenting with abdominal pain and fever might initially be suspected of having appendicitis. However, an ultrasound examination revealing mesenteric adenitis, a self-limiting condition, could obviate the need for an appendectomy. Furthermore, ultrasound can guide the selection of specific medical therapies. The visualization of free fluid, for instance, might prompt the initiation of antibiotics for suspected peritonitis. The ability to monitor the response to treatment in real-time using ultrasound adds another layer of dynamism to patient management. The benefits of ultrasound are particularly magnified in resource-constrained environments like Jakarta, where access to advanced imaging modalities may be limited. The portability, safety profile, and relative affordability of ultrasound render it an ideal tool for deployment in diverse clinical settings, from bustling emergency departments to remote primary care clinics. In Jakarta, where the burden of pediatric abdominal emergencies is significant, the ability to perform ultrasound examinations at the point of care

can be a game-changer. It enables rapid diagnosis and expeditious initiation of treatment, potentially mitigating the impact of delays associated with patient transport or waiting for imaging studies. Moreover, the avoidance of ionizing radiation, a concern particularly relevant in children, further strengthens the case for ultrasound as a first-line imaging modality. The findings of our study resonate with a growing chorus of research that champions the use of ultrasound in pediatric abdominal emergencies. Multiple studies across different geographical and socioeconomic contexts have documented the high sensitivity and specificity of ultrasound for diagnosing various abdominal conditions. Moreover, the impact of ultrasound on management decisions has been consistently observed, with studies reporting alterations in treatment plans in a significant proportion of cases. Our study contributes to this expanding body of evidence by providing valuable insights from a resource-constrained setting. We have shown that even in environments where access to advanced imaging may be challenging, ultrasound can be effectively leveraged to enhance the quality of care for children with acute abdominal pain. This reinforces the notion that POCUS is not merely a luxury but a necessity in the modern practice of pediatric emergency medicine. In the realm of pediatric abdominal emergencies, the stakes are high. A missed or delayed diagnosis can have devastating consequences. This study's findings underscore the exceptional diagnostic accuracy of ultrasound, particularly in identifying three critical conditions: appendicitis, intussusception, and the presence of free fluid in the abdomen. This precision is not merely a statistical triumph; it translates into tangible clinical benefits, empowering physicians to make informed, timely decisions that can significantly impact patient outcomes. Appendicitis, while a common surgical emergency in children, is notorious for its elusive presentation. Its symptoms can mimic a variety of other conditions, leading to diagnostic uncertainty and potential delays in treatment. The consequences of such delays can be severe, including perforation of the appendix, peritonitis, and sepsis. In this context, the high sensitivity and specificity of ultrasound in detecting appendicitis serve as a guiding light. The ability to visualize the appendix in real-time and identify hallmark signs of inflammation, such as a non-compressible, dilated appendix with a thickened wall, provides clinicians with a powerful tool to navigate the diagnostic maze. This visual confirmation can bolster clinical suspicion, expedite surgical consultation, and ultimately lead to timely appendectomy, minimizing the risk of complications and improving patient outcomes. Furthermore, in cases where the appendix appears normal on ultrasound, it can provide reassurance and potentially obviate the need for further imaging or invasive procedures. Intussusception, a condition in which one segment of the intestine telescopes into another, is a medical emergency that predominantly affects infants and young children. The hallmark symptom is severe, intermittent abdominal pain, often accompanied by vomiting and bloody stools. The consequences of delayed diagnosis and treatment can be dire, including bowel necrosis, perforation, and sepsis. Ultrasound's ability to readily visualize the characteristic “target sign” or “doughnut sign” associated with intussusception is a game-changer in this context. It enables rapid and accurate diagnosis at the bedside, facilitating prompt intervention. The definitive treatment for intussusception is often an enema, which can successfully reduce the telescoped bowel in many cases. The sooner the diagnosis is made and the enema is administered, the higher the likelihood of successful reduction and the lower the risk of complications. In this sense, ultrasound serves as a critical tool in the race against time to save the child's bowel and prevent life-threatening sequelae. The presence of free fluid in the abdomen, while not a diagnosis in itself, is a red flag that warrants immediate attention. It can signify a range of serious conditions, including hemorrhage, peritonitis, or ascites. The ability of ultrasound to rapidly and accurately detect free fluid at the point of care has profound implications for patient management. In cases of trauma, the identification of free fluid can prompt urgent surgical exploration to control bleeding and prevent hemorrhagic shock. In patients with suspected peritonitis, the presence of free fluid can

guide the decision to initiate broad-spectrum antibiotics and expedite surgical intervention if necessary. Similarly, in children with chronic liver disease or other conditions predisposing to ascites, ultrasound can aid in monitoring the progression of the disease and guiding therapeutic decisions. While the diagnostic accuracy statistics presented in this study are impressive, it's crucial to remember that behind every number lies a child in distress. The timely and accurate diagnosis afforded by ultrasound can translate into reduced pain and suffering, averted complications, and ultimately, saved lives. It empowers clinicians to make informed decisions, tailor treatment plans, and provide the best possible care to their young patients. Moreover, the use of ultrasound can alleviate anxiety and fear in both children and their parents. The non-invasive nature of the examination, coupled with the ability to visualize internal organs in real-time, can provide reassurance and foster trust in the healthcare team. This can be particularly important in the pediatric setting, where effective communication and patient comfort are paramount. The findings of this study, along with the growing body of evidence supporting the use of ultrasound in pediatric abdominal emergencies, suggest a paradigm shift in the diagnostic approach to these conditions. Ultrasound, once considered an adjunct to traditional imaging modalities, is emerging as a first-line tool in many clinical settings. Its portability, safety profile, real-time imaging capabilities, and cost-effectiveness make it an ideal choice for rapid and accurate assessment of children with acute abdominal pain. As ultrasound technology continues to advance and its applications expand, we can anticipate even greater integration of POCUS into the routine evaluation of pediatric patients. The potential benefits are immense, including improved diagnostic accuracy, streamlined patient care, reduced healthcare costs, and ultimately, better outcomes for children worldwide.[11,12]

In the fast-paced and often resource-constrained environment of emergency medicine, every decision matters. The findings of our study underscore the profound impact of point-of-care ultrasound (POCUS) on clinical decision-making in the context of pediatric abdominal emergencies. The observation that POCUS influenced management decisions in a staggering 68% of cases serves as a testament to its transformative potential in shaping the course of patient care. Furthermore, the fact that ultrasound findings led to a change in the initial management plan in nearly one-third of the patients highlights its tangible impact on therapeutic interventions. In the realm of pediatric abdominal emergencies, where symptoms can be vague and overlapping, POCUS acts as a guiding force, illuminating the path towards accurate diagnosis and appropriate management. The ability to visualize internal organs and pathology in real-time empowers clinicians to make informed decisions at the bedside, often obviating the need for time-consuming and resource-intensive investigations. For instance, in a child presenting with acute abdominal pain and suspected appendicitis, a POCUS examination can rapidly confirm or rule out the diagnosis. A positive ultrasound finding, demonstrating a non-compressible, dilated appendix with a thickened wall, can expedite surgical consultation and intervention, potentially preventing complications such as perforation and peritonitis. Conversely, a normal appendix on ultrasound can provide reassurance and avoid unnecessary appendectomy, sparing the child from the risks and burdens associated with surgery. Similarly, in cases of intussusception, where prompt diagnosis and treatment are critical, POCUS can be a lifesaver. The visualization of the characteristic “target sign” or “doughnut sign” can lead to immediate initiation of an enema, a procedure that can successfully reduce the telescoped bowel in many cases. The ability to monitor the reduction process in real-time using ultrasound further enhances the precision and effectiveness of the intervention. In resource-constrained settings like Jakarta, where access to advanced imaging modalities may be limited, the impact of POCUS on resource utilization is particularly significant. By providing rapid and accurate diagnostic information at the point of care, ultrasound can reduce the need for costly and time-consuming investigations such as CT scans or MRIs. This not only translates into cost savings for the healthcare system but also minimizes patient

exposure to ionizing radiation, a concern especially pertinent in children. Furthermore, POCUS can help streamline patient flow in the emergency department. By enabling clinicians to make timely and informed decisions regarding the need for admission, observation, or discharge, ultrasound can optimize bed utilization and reduce overcrowding. This can have a cascading effect on the overall efficiency of the emergency department, improving the quality of care for all patients. The impact of POCUS extends beyond resource optimization. By facilitating prompt diagnosis and targeted interventions, ultrasound can potentially improve patient outcomes. Early diagnosis of conditions like appendicitis or intussusception can lead to timely treatment, reducing the risk of complications and improving recovery rates. Avoiding unnecessary surgeries or procedures can minimize patient morbidity and shorten hospital stays. Moreover, the use of POCUS can enhance patient satisfaction and trust in the healthcare system. The ability to visualize internal organs in real-time can provide reassurance to both children and their parents, fostering a sense of transparency and collaboration in the care process. This can be particularly important in the pediatric setting, where effective communication and patient comfort are paramount. The findings of this study, coupled with the growing body of evidence supporting the use of ultrasound in pediatric abdominal emergencies, call for a concerted effort to expand the reach of POCUS in resource-constrained settings. This involves not only investing in ultrasound equipment but also developing sustainable training programs to empower clinicians with the knowledge and skills necessary to effectively utilize this powerful tool. By integrating POCUS into routine clinical practice, we can bridge the gap in access to advanced imaging modalities, optimize resource utilization, and ultimately, improve the quality of care for children with acute abdominal pain. The ripple effects of this transformation can extend far beyond the individual patient, impacting the overall efficiency and effectiveness of the healthcare system.[13,14]

In the bustling metropolis of Jakarta, where the pulse of life beats with unrelenting energy, the healthcare system faces a formidable challenge: providing timely and effective care to a burgeoning population, especially its most vulnerable members – the children. The burden of pediatric abdominal emergencies in this rapidly growing city is substantial, with a high incidence of conditions such as appendicitis, intussusception, and gastroenteritis demanding swift and accurate diagnosis. However, access to healthcare resources, particularly advanced imaging modalities, remains a persistent hurdle, especially in underserved areas where socioeconomic disparities cast long shadows. In this complex and demanding landscape, ultrasound emerges as a beacon of hope, offering a multitude of advantages that make it an indispensable tool in the diagnosis and management of pediatric abdominal emergencies. Its portability, safety profile, cost-effectiveness, and real-time imaging capabilities converge to create a powerful solution that can bridge the gap in access to healthcare and empower clinicians to deliver optimal care to their young patients. One of the most compelling advantages of ultrasound is its portability. Unlike traditional imaging modalities such as computed tomography (CT) or magnetic resonance imaging (MRI), which require dedicated facilities and specialized personnel, ultrasound machines have become increasingly compact and mobile. This portability allows for the deployment of ultrasound in a variety of clinical settings, from bustling emergency departments to remote primary care clinics and even makeshift field hospitals. In the context of Jakarta, where traffic congestion and geographical barriers can impede access to healthcare, the portability of ultrasound is a game-changer. It enables clinicians to bring healthcare to the doorstep, so to speak, performing examinations at the point of care and reducing the need for patient transport and potential delays in diagnosis and treatment. This is particularly crucial in emergency situations, where every minute counts. Another salient advantage of ultrasound is its inherent safety. Unlike CT scans, which utilize ionizing radiation, ultrasound employs sound waves to generate images, eliminating the risk of radiation exposure. This is of paramount importance in the pediatric population, where the long-term effects of

radiation are a major concern. Children are particularly susceptible to the harmful effects of radiation due to their rapidly dividing cells and longer life expectancy. By obviating the need for ionizing radiation, ultrasound offers a safe and effective alternative for imaging the abdomen in children, safeguarding their health and well-being. In a city like Jakarta, where healthcare resources are often stretched thin, the cost-effectiveness of ultrasound is a significant advantage. Compared to other imaging modalities, ultrasound is relatively inexpensive, both in terms of equipment costs and operational expenses. This makes it an attractive option for resource-constrained settings, where maximizing the impact of limited resources is a constant challenge. Furthermore, the ability to perform ultrasound examinations at the point of care can lead to cost savings by reducing the need for patient transport, hospital admissions, and unnecessary procedures. For instance, a child with suspected appendicitis who undergoes a POCUS examination in the emergency department may be diagnosed and treated promptly, avoiding the need for a CT scan and potential hospital admission. This not only benefits the individual patient but also contributes to the overall efficiency and sustainability of the healthcare system. Ultrasound's real-time imaging capabilities offer a unique window into the dynamic world of the human body. Unlike static images produced by CT or MRI, ultrasound allows clinicians to visualize organ motion, blood flow, and the presence of free fluid in real-time. This can be particularly valuable in the assessment of pediatric abdominal emergencies, where subtle findings or changes over time can provide crucial diagnostic clues. For example, in a child with suspected intussusception, ultrasound can not only identify the characteristic “target sign” but also demonstrate the dynamic process of bowel telescoping and potential reduction with an enema. This real-time visualization can guide therapeutic decisions and monitor the effectiveness of interventions, leading to more personalized and effective care. The advent of POCUS has empowered clinicians across various specialties to expand their diagnostic and therapeutic capabilities. In Jakarta, where access to specialized radiologists may be limited, especially in remote or underserved areas, the ability of primary care physicians, emergency physicians, and even nurses to perform and interpret basic ultrasound examinations can be transformative. It can enable them to make timely diagnoses, initiate appropriate treatment, and refer patients for further evaluation or intervention when necessary. This democratization of ultrasound has the potential to revolutionize healthcare delivery in resource-constrained settings. By empowering frontline clinicians with this powerful tool, we can bridge the gap in access to specialized care and improve the quality of life for countless children in need.[15,16]

The findings of our study harmonize with a growing symphony of research that extols the virtues of ultrasound in the realm of pediatric abdominal emergencies. Across the globe, numerous studies have documented the high sensitivity and specificity of ultrasound in diagnosing a range of conditions, from the common scourge of appendicitis to the insidious threat of intussusception. Furthermore, the impact of ultrasound on clinical decision-making has been well-established, with evidence suggesting that it can alter the initial management plan in a significant proportion of cases. This study, however, adds a unique and crucial voice to this global chorus. By focusing on a resource-constrained setting like Jakarta, Indonesia, we have demonstrated that the benefits of ultrasound are not confined to affluent nations with abundant healthcare resources. Even in environments where access to advanced imaging modalities may be limited, ultrasound can be effectively wielded to improve the quality of care for children with acute abdominal pain. Our findings underscore the potential of ultrasound to bridge the chasm in access to specialized care, empowering clinicians in underserved areas to make timely and accurate diagnoses, guide therapeutic interventions, and ultimately, improve patient outcomes. Several studies conducted in diverse settings have reported impressive diagnostic accuracy rates for ultrasound in identifying common pediatric abdominal emergencies. For instance, a systematic review and meta-analysis published in *Pediatrics* in 2018 found that the pooled sensitivity and specificity

of ultrasound for diagnosing appendicitis were 86% and 94%, respectively. Similarly, studies evaluating the use of ultrasound for intussusception have reported sensitivity and specificity ranging from 90% to 100%. These findings are remarkably consistent with our own observations, further solidifying the evidence base for ultrasound as a reliable diagnostic tool in this context. Moreover, the impact of ultrasound on management decisions has been well documented in the literature. A study published in *Academic Emergency Medicine* in 2019 found that the use of POCUS in the emergency department led to a change in management in 42% of children with abdominal pain. Another study reported that POCUS altered the management plan in 31% of patients with suspected appendicitis, leading to increased rates of non-operative management and decreased time to surgery. These findings echo our own observations, where POCUS influenced management decisions in 68% of cases and led to a change in the initial management plan in 32% of patients. While previous studies have laid a solid foundation for understanding the role of ultrasound in pediatric abdominal emergencies, our study adds a unique perspective by focusing on a resource-constrained setting. Jakarta, with its burgeoning population and limited healthcare resources, presents a microcosm of the challenges faced by many developing nations. In this context, the ability of ultrasound to provide rapid, accurate, and affordable imaging at the point of care is particularly valuable. Our findings demonstrate that even in an environment where access to CT scans or MRIs may be restricted, ultrasound can be effectively utilized to improve the diagnostic and therapeutic capabilities of clinicians. This has significant implications for healthcare delivery in underserved areas, where the burden of pediatric abdominal emergencies is often high. By empowering frontline clinicians with the ability to perform and interpret basic ultrasound examinations, we can bridge the gap in access to specialized care and ensure that every child receives the timely and effective treatment they deserve. While our study aligns with previous research in many respects, it also ventures beyond the echo chamber by exploring the unique challenges and opportunities presented by a resource-constrained setting. We have shown that ultrasound can be a powerful tool for improving the quality of care for children with acute abdominal pain, even in environments where resources are limited. This has implications not only for clinical practice but also for healthcare policy and resource allocation. Furthermore, our study underscores the importance of context in evaluating the role of ultrasound. While its diagnostic accuracy and impact on management decisions are well-established, the specific ways in which ultrasound is utilized and its potential benefits may vary depending on the setting. In resource-constrained environments, ultrasound's portability, safety profile, and cost-effectiveness may be particularly salient, whereas in settings with greater access to advanced imaging modalities, its role may be more focused on point-of-care decision-making and triage. The findings of this study, along with the wealth of evidence from previous research, serve as a clarion call to amplify the ultrasound signal in the global arena of pediatric emergency medicine. We must invest in ultrasound training and education, particularly in resource-constrained settings, to empower clinicians with the skills and confidence to utilize this powerful tool effectively. We must advocate for policies that promote the integration of POCUS into routine clinical practice, ensuring that every child, regardless of their geographical location or socioeconomic circumstances, has access to timely and accurate diagnosis and treatment. By embracing the potential of ultrasound, we can transform the landscape of pediatric abdominal emergencies, reducing diagnostic uncertainty, optimizing resource utilization, and ultimately, improving the lives of countless children worldwide. The echoes of this transformation will reverberate far beyond the walls of the emergency department, creating a ripple effect that benefits the entire healthcare system and the communities it serves. The time to act is now. Let us heed the call and harness the power of ultrasound to build a brighter and healthier future for our children.[17,18]

The integration of point-of-care ultrasound (POCUS) into the clinical workflow is not merely a matter of acquiring the latest technology; it demands

a concerted investment in training and education. While ultrasound machines have become increasingly user-friendly, their true potential can only be unlocked through the acquisition of specific knowledge and skills. The successful implementation of POCUS hinges on equipping healthcare providers with the competence to acquire high-quality images, interpret them accurately, and translate those interpretations into sound clinical decisions. This necessitates a multifaceted approach to training and education that encompasses both theoretical knowledge and hands-on experience. Effective POCUS training programs typically rest on three pillars: knowledge, skills, and attitude. The knowledge component involves imparting a solid understanding of ultrasound physics, image acquisition techniques, and the sonographic anatomy of relevant organ systems. This theoretical foundation lays the groundwork for image interpretation and clinical decision-making. The skills component focuses on developing proficiency in image acquisition and interpretation. Hands-on workshops, simulation exercises, and supervised scanning sessions provide opportunities for learners to hone their technique and gain confidence in their ability to identify normal and pathological findings. Finally, the attitude component emphasizes the importance of critical thinking, ethical considerations, and patient-centered care. Learners are encouraged to adopt a reflective approach to their practice, continuously evaluating their skills and seeking opportunities for improvement. They are also reminded of the ethical implications of POCUS, including the need for informed consent, appropriate use of the technology, and avoidance of overdiagnosis or overtreatment. A variety of training modalities can be employed to foster POCUS proficiency. Didactic lectures, online courses, and textbooks can provide a comprehensive overview of ultrasound physics, anatomy, and pathology. Hands-on workshops and simulation exercises allow learners to practice image acquisition and interpretation in a controlled environment. Supervised scanning sessions with experienced mentors offer valuable feedback and guidance. Image review sessions, where learners analyze and discuss ultrasound images with experts, can further enhance their interpretive skills and clinical reasoning. Case-based learning, where learners apply their knowledge and skills to real-world clinical scenarios, can bridge the gap between theory and practice. In resource-constrained settings like Jakarta, the development of sustainable training programs is crucial to ensure the widespread adoption and effective utilization of POCUS. This may involve training local clinicians as POCUS instructors who can then cascade their knowledge and skills to other healthcare providers in their communities. This "train-the-trainer" model can be particularly effective in overcoming barriers to access and ensuring the long-term sustainability of POCUS training. Additionally, telemedicine and online learning platforms can be leveraged to provide remote training and support to clinicians in underserved areas. These platforms can offer a wealth of educational resources, including video lectures, interactive modules, and image libraries. Remote mentorship and image review sessions can also be conducted via telemedicine, providing clinicians with expert guidance and feedback. The implementation of POCUS training programs is not without its challenges. In resource-constrained settings, access to ultrasound equipment, trained instructors, and educational materials may be limited. Furthermore, time constraints and competing clinical demands can make it difficult for healthcare providers to dedicate sufficient time to training. To overcome these challenges, creative solutions are needed. Partnerships with international organizations, universities, and non-governmental organizations can help secure funding and resources for POCUS training. The development of low-cost, portable ultrasound machines can further enhance accessibility in underserved areas. Task-shifting, where non-physician healthcare providers are trained to perform basic ultrasound examinations, can also be a viable strategy to address workforce shortages.[19,20]

4. Conclusion

This study illuminates the invaluable role of ultrasound in the diagnosis and management of pediatric abdominal emergencies within the context of Jakarta, Indonesia. Its high diagnostic accuracy for common conditions, coupled with its capacity to

significantly influence management decisions, underscores its potential to elevate the standard of care in resource-constrained settings. Ultrasound's portability, safety profile, and cost-effectiveness render it an ideal tool for bridging the gap in access to advanced imaging modalities, empowering clinicians to deliver timely and effective care to children in need.

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