The Journal of Emergency Medicine, Vol. ■, No. ■, pp. 1–6, 2017

0736-4679/$ - see front matter

http://dx.doi.org/10.1016/j.jemermed.2017.01.003

Selected Topics: Emergency Radiology

ULTRASOUND FOR DIAGNOSIS OF APPENDICITIS IN A COMMUNITY HOSPITAL EMERGENCY DEPARTMENT HAS A HIGH RATE OF NONDIAGNOSTIC STUDIES

Scott M. Alter, MD,* Brian Walsh, MD,† Patrick J. Lenehan, MD,‡ and Richard D. Shih, MD*

*Division of Emergency Medicine, Charles E. Schmidt College of Medicine, Florida Atlantic University, Boca Raton, Florida, †Department of Emergency Medicine, Morristown Medical Center, Morristown, New Jersey, and ‡Department of Emergency Medicine, California Hospital Medical Center, Los Angeles, California

Reprint Address: Scott M. Alter, MD, Division of Emergency Medicine, Florida Atlantic University at Bethesda Health, 2815 South Seacrest Blvd, Boynton Beach, FL 33435

☐ **Abstract—Background: Radiation concerns are changing the way emergency physicians evaluate patients. This is especially prevalent in pediatrics, and exemplified by abdominal pain management. Large academic center-based studies suggest appendix ultrasound (U/S) is sensitive and specific for appendicitis, with low nondiagnostic rates. Objectives: We sought to determine the diagnostic rate of appendix U/S and incidence of follow-up computed tomography (CT) imaging for pediatric patients at a community hospital. Methods: Design: Retrospective cohort. Setting: Emergency department with 85,000 annual visits. Population: Patients younger than 21 years old that had an appendix U/S over a 12-month period. U/S were performed by technicians and interpreted by radiologists. Investigators classified readings as "diagnostic" ("positive" and "negative") or "non-diagnostic" ("borderline" and "appendix not visualized") and identified follow-up CT studies and interpretations. Results: There were 441 pediatric appendix U/S performed; 26% were diagnostic (14% positive for appendicitis, 12% negative) and 74% nondiagnostic (5% borderline, 69% appendix not visualized). Follow-up CT scans were obtained in 19% of all patients, including 8% with positive U/S, 4% negative, 32% borderline, and 22% not visualized. Follow-up CT was nearly four times more likely in the nondiagnostic group than the diagnostic group (23% vs. 6%, $p < 0.0001$). Conclusion: The utility of U/S to diagnose appendicitis at a community hospital is limited by a high rate of nondiagnostic studies. Some patients with diagnostic U/S even had follow-up CT imaging. To minimize radiation exposure in children, improvements should be made in the performance and acceptance of U/S as the primary modality of abdominal pain imaging at community hospitals.**

☐ **Keywords—ultrasound; appendix; pediatrics; emergency; community**

INTRODUCTION

The most common atraumatic surgical emergency in the pediatric age group is appendicitis (1). Physical examination alone is often not reliable enough for a surgeon to take a patient to the operating room. Therefore, additional diagnostic testing and imaging are utilized to determine a definitive diagnosis.

Without the use of imaging, clinical examination and laboratory findings are the predominant tools utilized in the diagnosis of pediatric appendicitis. The most useful sign associated with appendicitis with the greatest likelihood ratio is fever; rebound tenderness, migration of pain, and leukocytosis are also helpful (2). Presence of pain upon hopping or walking increases the odds of appendicitis (3). White blood cell count >12 $\times$ $10^3/\mu$L and leukocyte left shift in pediatric patients with nontraumatic abdominal pain have been shown to have high sensitivity

RECEIVED: 6 July 2016; FINAL SUBMISSION RECEIVED: 1 January 2017;
ACCEPTED: 4 January 2017

and specificity for appendicitis (3,4). C-reactive protein level >3 mg/dL also has been shown to be predictive of appendicitis, and in combination with elevated white blood cell count has an odds ratio of 7.75 (3). Utilizing white blood cell count with signs and symptoms, the Alvarado score was devised as a tool in appendicitis diagnosis (5). Although this score may identify predictive factors, some studies have found it not to be reliable enough to exclude appendicitis in patients with low probability scores (6,7).

Historically, computed tomography (CT) imaging of the abdomen/pelvis has been the best diagnostic test for imaging of the appendix. This CT for diagnosis of acute appendicitis has excellent sensitivity, specificity, and positive predictive value, all with percentages in the mid to high 90s, with fair negative predictive value, from 71–96% (6–9). However, concerns over radiation and contrast exposure have detracted from this being the first-line imaging for pediatrics. Contrast-induced nephropathy, generally defined as a >25% increase in serum creatinine levels over baseline, is not uncommon. Rates can vary from 0% to 90%, depending on risk factors, but the incidence in a healthy general population may be as low as 1–2% (10–12). As most children are generally without major health problems, the greater concern is the potential for malignancy from exposure to ionizing radiation. Pediatric CT imaging results significantly increased lifetime radiation risk when compared with adult CT imaging (13). It is estimated that CT imaging may lead to one malignant transformation for every 500 pediatric CT scans performed, which is around a 10-times greater risk than in adults (14,15). Due to this radiation risk, some research has suggested reducing radiation exposure during CT of the abdomen/pelvis (16). One study with a 39% reduction in median absorbed radiation dose found no change in sensitivity or specificity for appendicitis diagnosis (17). However, even with reduced radiation exposure there continues to be risk of malignancy, and the potential side effects have continued to limit CT imaging in pediatrics.

Over the past three decades, ultrasonography has emerged as a viable alternative for imaging the appendix and is frequently used in the diagnostic evaluation of appendicitis. There is evidence to suggest, however, that after an initial surge, its use had been waning in favor of CT in the late 2000s (18). As a response to overuse of CT imaging, collaborators in the State of Washington created the Safe and Sound campaign as an attempt to continue to reduce CT imaging and promote high-quality ultrasound (U/S) imaging (18). More and more studies suggest increasing accuracy of U/S of the appendix, with sensitivities percentage generally in the high 80s and higher specificities percentage in the mid–low 90s (8,9,19,20). These studies tend to be at large, academic centers and may not reflect the real-world practice of how the test is performed and interpreted.

Our experience at a community hospital did not seem to be aligned with other published statistical measures of the utility of U/S of the appendix, as we were experiencing a greater rate of nondiagnostic U/S with high rates of follow-up CT imaging. Therefore, our goal of this study was to examine the diagnostic rate of U/S for appendicitis in a community setting, as well as the frequency of follow-up CT abdomen/pelvis imaging.

MATERIALS AND METHODS

Design and Setting

This study is a retrospective cohort study performed at a community teaching hospital with 85,000 emergency department (ED) visits per year.

Selection of Participants

Consecutive pediatric ED patients (<21 years old) who underwent an appendix ultrasound between January 1, 2012 and December 31, 2012 were enrolled.

Methods and Measurements

We queried the picture archiving and communication system database for pediatric patients who had an ultrasound of the appendix performed. Patients were excluded if the ultrasound order was not placed by an emergency physician. For each patient, we also recorded any follow-up CT abdomen/pelvis imaging performed after the U/S appendix and during the same ED visit, also obtained from the picture archiving and communication system database. The decision to order an U/S, as well as any subsequent CT, was at the discretion of the treating emergency medicine attending physician. American Registry for Diagnostic Medical Sonography-certified sonographers performed all U/S based on standard department protocol: using the classic graded compression technique with 6–15-MHz linear-array probes. One of 14 board-certified radiologists interpreted each U/S study, though some cases had initial preliminary readings provided by radiology residents prior to attending over-reading.

Two study investigators reviewed all of the U/S final radiology reports and classified the reading for appendicitis as “positive,” “negative,” “borderline,” or “not visualized.” Positive was defined as a report that diagnosed appendicitis. Negative was defined as a report that either the radiologist diagnosed as not appendicitis or identified a normal appendix. Borderline was a report that mentioned any abnormal or equivocal findings possibly related to appendicitis, without the diagnosis