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Improving ultrasound for appendicitis through standardized reporting of secondary signs

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ABSTRACT

Objective: Our aim was to implement a standardized US report that included secondary signs of appendicitis (SS) to facilitate accurate diagnosis of appendicitis and decrease the use of computed tomography (CT) and admissions for observation.
Methods: A multidisciplinary team implemented a quality improvement (QI) intervention in the form of a standardized US report and provided stakeholders with monthly feedback. Outcomes including report compliance, CT use, and observation admissions were compared pretemplate and posttemplate.
Results: We identified 387 patients in the pretemplate period and 483 patients in the posttemplate period. In the posttemplate period, the reporting of SS increased from 5.4% to 79.5% ($p < 0.001$). Despite lower rates of appendix visualization (43.9% to 32.7%, $p < 0.001$) with US, overall CT use (8.5% vs 7.0%, $p = 0.41$) and the negative appendectomy rate remained stable (1.0% vs 1.0%, $p = 1.0$). CT utilization for patients with an equivocal ultrasound and SS present decreased (36.4% vs 8.9%, $p = 0.002$) and admissions for observations decreased (21.5% vs 15.3%, $p = 0.02$). Test characteristics of RLQ US for appendicitis also improved in the posttemplate period.
Conclusion: A focused QI initiative led to high compliance rates of utilizing the standardized US report and resulted in lower CT use and fewer admissions for observation.
Study of a Diagnostic Test Level of Evidence: 1.

1. Problem description and available knowledge

Appendicitis remains the leading cause of pediatric abdominal pain requiring emergent surgery [1]. Despite the prevalence of appendicitis, the clinical diagnosis remains challenging resulting in the use of diagnostic imaging. Ultrasound (US) of the right lower quadrant (RLQ) is recommended by the American College of Radiology and the American Academy of Pediatrics as the initial imaging modality in evaluating pediatric appendicitis [2,3]. If the appendix is not visualized on US, then clinicians may doubt the US findings and utilize computed tomography scans (CT) or admissions for observation to assist in the diagnosis. CTs are an accurate diagnostic tool with reports of sensitivity (SN) ranging from 95 to 97% and specificity (SP) ranging from 94 to 97% [4], but are more expensive than US and expose children to ionizing radiation, increasing their risk of subsequent cancer development [5–8]. When the appendix is fully visualized, US can be as sensitive, specific, and accurate as CT [4,9–11]; however, US is user-dependent as reflected by a wide appendix visualization rate ranging from 40% to 89% [11–15].

1.1. Problem

Absolute indications for subsequent imaging or admission for observation have not been clearly defined. Wide practice variation exists within and between children's hospitals and nonchildren's hospitals, resulting in inconsistent costs and resource utilization [16–18]. Radiologists commonly record US findings in a free-handed US report. If the appendix is not visualized, then the impression is often a restatement of the nonvisualization of the appendix and suggestion of clinical correlation. The impressions of the equivocal US studies are thought to lack diagnostic information, so physicians then ordered CT, admission for observation, or both.

In an effort to increase the diagnostic accuracy of US, investigators have proposed combining equivocal US studies with additional data such as secondary signs (SS) of appendicitis [15,19–22]. SSs are sonographic descriptions of inflammation surrounding the appendix and include fluid collections, free fluid, echogenic fat, hyperemia, abnormal

Abbreviations: CT, computed tomography scans; PAS, pediatric appendicitis score; QI, quality improvement; RLQ, right lower quadrant; SN, sensitivity; SP, specificity; SS, secondary signs of appendicitis; US, ultrasound.

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lymph nodes, abnormal adjacent bowel, bowel wall edema, and appendicoliths [19,23].

1.2. Rationale

Standardized reporting of US findings has been suggested as a means to provide clinicians with as much information as possible of many sonographic details and could assist in diagnosis even when the appendix is not fully visualized [19,20,22,24,25].

1.3. Specific aim

In order to optimize utility of US at our institution, we implemented a quality improvement (QI) initiative to increase the reporting of SS in RLQ US. Concurrently, we tracked the number of patients undergoing CT and the number of patients being admitted for observation.

2. Methods

2.1. Context

The QI effort took place at the Egleston Campus of the Children's Healthcare of Atlanta (Atlanta, GA), a free-standing, university-affiliated, tertiary care pediatric hospital where more than 300 appendectomies are performed annually. The hospital serves children of all ages; however, we limited our study to children 5 to 18 years old. Age limits were used in concordance with ongoing efforts to utilize imaging for appendicitis diagnosis after use of a Pediatric Appendicitis Score (PAS) which requires patients to verbally describe symptoms. The emergency department, radiology, and surgical services are staffed by pediatric specialized attendings, staff, and trainees.

2.2. Intervention

Practice in our center is to have patients with concern for appendicitis assessed by emergency medicine physicians who determine the initial workup such as imaging studies. All USs were performed by a radiology technician. Before our QI intervention, the US reports were dictated in an unstructured fashion by radiologists. When the appendix was not visualized, the impression often restated nonvisualization of the appendix and recommended clinical correlation. This process resulted in follow-up imaging in the form of CT, admission to the surgical service for observation, or both. Prior work from our group and others demonstrated that US reports that include details such as the presence or absence of specific SS may provide clinicians with reliable information even in the setting of a nonvisualized or partially visualized appendix [19,20,22,24,25]. A multidisciplinary team of pediatric emergency medicine physicians, pediatric radiologists, pediatric surgeons, nurses, and QI personnel instituted a QI intervention to standardize the reporting of SS on US and to decrease the proportion of patients undergoing CT and being admitted for observation.

An aim to reduce CT use by 50% for patients with equivocal US was established for a 6-month time-frame (posttemplate period) with an additional 6 months of observation (sustainability period, Fig. 1). During the posttemplate period, the multidisciplinary QI team met monthly to assess the use of the standardized report as well as address any specific concerns that were limiting the use of the template. During the sustainability period, formal meetings took place quarterly. Key drivers focused on standardization. A standardized US report template was adopted and uploaded to the electronic medical record reporting system [20].

2.3. Study of the intervention

The success of the implementation of the standardized report was assessed by the increase in compliance of radiologists using the US report over time and the relative decrease in the proportion of patients with equivocal US studies undergoing CT or being admitted for observation. We defined compliance both as all seven SSs mentioned and at least 5 of the 7 SSs mentioned as we wanted acknowledge improved reporting even if it was imperfect. The study was a retrospective analysis of children (5–18 years old) with concern for appendicitis who underwent RLQ US from January 1, 2014 to December 31, 2015. We initiated a standardized US report that included appendix measurements, categorization of the appendix, and seven SSs on January 1, 2015. To ensure generalizability, we aimed for our cohort to be as inclusive as possible. We used language recognition software to examine the chief complaints as listed in the electronic medical record and included all patients with chief complaints that included the terms: “abd,” “appy,” “stomach,” “appendicitis,” and “rlq.” Of these patients that we identified as having concern for appendicitis, we included all patients that received an RLQ US in order to evaluate the appendix. Patients were excluded if they underwent a US or CT for their abdominal pain at an outside hospital, if they had a prior appendectomy, if they were already being nonoperatively managed for perforated appendicitis, or if they did not have abdominal pain. To ensure the integrity of the data, two reviewers (AP, KP) abstracted data from charts, and all final data were reviewed for accuracy by a single reviewer (KP).

The outcomes of interest were captured by the electronic medical record, and each admission note was reviewed to determine the clinical indication for admission. Final US reports were reviewed for primary and secondary signs of appendicitis. The primary sign of appendicitis was a fully visualized appendix with a diameter greater than or equal to 6 mm [19]. SS included fluid collections consistent with abscesses (fluid collections), a significant amount of abdominal free fluid (free fluid), hyperechogenicity of periappendiceal fat (echogenic fat), increased regional bowel vascularity (hyperemia), the presence of enlarged or supranumery mesenteric lymph nodes (abnormal lymph nodes), hypoperistalsis or dilation of adjacent bowel loops (abnormal adjacent bowel), bowel wall edema, and appendicoliths [19,23]. As has been previously described, US reports were classified into four categories: 1, normal; 2, equivocal without SS; 3, equivocal with SS; and 4, appendicitis [19,20,26]. Categories 1 and 4 included a fully visualized appendix and were collectively referred to as unequivocal. Categories 2 and 3 included US in which the appendix was not fully visualized and were collectively referred to as equivocal. The final diagnosis of each patient was recorded as either appendicitis or not appendicitis. Appendicitis was confirmed through review of operative reports, pathology results, and CT impressions when CT was performed. Each patient's electronic medical record was examined for details regarding the clinical course and any readmissions. For patients diagnosed as not having appendicitis, chart review ensured that appendicitis was not diagnosed in the 30 days after the initial presentation).

2.4. Intervention implementation

Implementation of the standardized US report began with personal communication of the successful implementation of similar programs at other children's hospitals [20]. In order to shift the culture at our institution, several retrospective reviews were performed to validate the need to include SS in the reports and to educate clinicians regarding the reliability of SS as important variables to consider in making a diagnosis of appendicitis. The first assessed which SSs were most highly associated with appendicitis [22]. The second demonstrated that SSs were associated with duration of symptoms. Results of these studies were shared in local forums, QI meetings, and national meetings. Radiology champions (JL, KB), who were involved from the project start, facilitated consensus regarding the specific elements included in the final report, education for all radiology staff members, and dissemination of the templates in electronic form for ease of use. Initial iterations of the standardized report included SS. Subsequent versions also included a final classification into one of four categories as previously outlined. Fig. 2 provides a p-chart demonstrating trends over time.