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Association for Academic Surgery

Standardized ultrasound templates for diagnosing appendicitis reduce annual imaging costs

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ARTICLE INFO

Article history:
Received 13 February 2017
Received in revised form
13 May 2017
Accepted 3 July 2017
Available online xxx

Keywords:
Appendicitis
Ultrasound
Computed tomography
Cost analysis

ABSTRACT

Background: Ultrasound is preferred over computed tomography (CT) for diagnosing appendicitis in children to avoid undue radiation exposure. We previously reported our experience in instituting a standardized appendicitis ultrasound template, which decreased CT rates by 67.3%. In this analysis, we demonstrate the ongoing cost savings associated with using this template.

Methods: Retrospective chart review for the time period preceding template implementation (June 2012-September 2012) was combined with prospective review through December 2015 for all patients in the emergency department receiving diagnostic imaging for appendicitis. The type of imaging was recorded, and imaging rates and ultrasound test statistics were calculated. Estimated annual imaging costs based on pretemplate ultrasound and CT utilization rates were compared with post-template annual costs to calculate annual and cumulative savings.

Results: In the pretemplate period, ultrasound and CT rates were 80.2% and 44.3%, respectively, resulting in a combined annual cost of $300,527.70. Similar calculations were performed for each succeeding year, accounting for changes in patient volume. Using pretemplate rates, our projected 2015 imaging cost was $371,402.86; however, our ultrasound rate had increased to 98.3%, whereas the CT rate declined to 9.6%, yielding an annual estimated cost of $224,853.00 and a savings of $146,549.86. Since implementation, annual savings have steadily increased for a cumulative cost savings of $336,683.83.

Conclusions: Standardizing ultrasound reports for appendicitis not only reduces the use of CT scans and the associated radiation exposure but also decreases annual imaging costs despite increased numbers of imaging studies. Continued cost reduction may be possible by using diagnostic algorithms.

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http://dx.doi.org/10.1016/j.jss.2017.07.002

Introduction

Appendicitis is the most common surgical abdominal emergency in children, with an incidence of approximately 8%. Although the disease often progresses predictably, variations in presentation may confound the diagnosis, particularly in younger children who are unable to communicate their symptoms.[1] Laboratory and radiologic studies are therefore crucial adjuncts to avoid delays in diagnosis and treatment.

The most common imaging studies used to diagnose appendicitis are ultrasound and computed tomography (CT). Although ultrasound is less expensive, noninvasive, and involves no radiation, it is highly operator dependent, with generally lower published sensitivities than CT. Furthermore, ultrasound may not be as readily available as CT, especially outside of dedicated pediatric facilities. Although CT is more sensitive and not operator dependent, its use entails radiation exposure and the administration of potentially nephrotoxic intravenous contrast.[1] The amount of radiation exposure is not negligible because the developing tissues of the child are more sensitive to its effects. Projections estimate that abdomen/pelvis CTs result in the development of a solid tumor for every 300-390 scans in girls and 670-760 scans in boys.[2]

Not only do CT scans increase the lifetime risk of malignancy, they are also more expensive than ultrasound: one estimate suggests that routine ultrasound use before CT saves approximately $450 per patient in imaging costs alone.[3] This potential savings should be considered in the context of rising United States health care costs, which have steadily increased for over 3 decades.[4] The application of new technologies, primarily imaging tests, drives the majority of this increase, and multiple studies suggest that such tests are overutilized, with results that may not alter patient care.[5,6]

Due to these concerns regarding CT usage, current American College of Radiology guidelines recommend ultrasound use before CT in children and adolescents with suspected appendicitis.[7] At our institution, in addition to adopting these guidelines, we developed a standardized ultrasound template for appendicitis (Fig. 1), which classifies sonographic findings into one of four categories, two of which are considered positive for appendicitis and two of which are considered negative.[8] Usage of this template improved ultrasound accuracy and decreased the CT rate from 44.3% to 14.5%.[8] We sought to demonstrate that ongoing application of the ultrasound template would continue to decrease CT usage without sacrificing diagnostic accuracy, and that these trends are associated with decreased overall imaging costs over time.

Methods

This study is part of an ongoing quality improvement project to decrease CT utilization in diagnosing appendicitis; as such, it is exempt from IRB approval (IRB# 13-00734). Our study population included all patients under 18 y of age presenting to the emergency department (ED) of a free-standing pediatric tertiary care hospital who received diagnostic imaging, either ultrasound or CT, for suspected appendicitis. Patients were excluded if they received either study for another diagnosis, if the study was performed at a referring hospital, or if they had previously undergone appendectomy. Charts were reviewed for the type of imaging performed, imaging findings, final diagnosis, usage of the ultrasound template, and whether ultrasound findings were concordant with CT (were performed). For patients proceeding to appendectomy, the intraoperative findings and final pathology results were also recorded, with appendicitis defined as transmural inflammation of the appendix on histologic examination.

From these data, we calculated ultrasound and CT rates. Imaging rates were calculated as the number of respective studies performed annually divided by the total number of patients per year. CT rates were analyzed using statistical process control methodology with Shewhart control charts. For these charts, process means were established based on 6-8 consecutive values, and control limits are set at three standard deviations from the process mean. Variation within these limits represents expected common cause variation, and values outside these limits suggest the influence of an external

***Appendix:**	The appendix is identified in the right lower quadrant
***Appendix size:**	The appendix is less than 7 mm in outer diameter
Wall thickness:	Normal, less than 1.7 mm in thickness
Appendicolith:	No appendicolith was identified
Perforation:	None
[+]Abscess:	None
[+]Periappendiceal fat:	The periappendiceal fat is normal
Vascularity:	Normal vascularity was observed without hyperemia
Mesenteric lymph nodes:	No pathologically large lymph nodes were observed
[+]Adjacent bowel loops:	Peristalsing normal-appearing bowel loops were observed
Additional abnormalities:	None
Impression:	Normal appendix without secondary features of appendicitis

Fig. 1 – Sample ultrasound template demonstrating negative findings for appendicitis. *Primary criteria for appendicitis. [+]Approved secondary signs. Based on the template, ultrasounds are categorized in to one of the four ways: no sonographic evidence of appendicitis, incompletely visualized appendix without secondary signs, incompletely visualized appendix with secondary signs, and acute appendicitis.