

Trends in the Use of Medical Imaging to Diagnose Appendicitis at an Academic Medical Center

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Abstract

Objective: To quantify the trends in imaging use for the diagnosis of appendicitis.

Methods: A retrospective study covering a 22-year period was conducted at an academic medical center. Patients were identified by International Classification of Diseases-9 diagnosis code for appendicitis. Medical record data extraction of these patients included imaging test used (ultrasound, CT, or MRI), gender, age, and body mass index (BMI). The proportion of patients undergoing each scan was calculated by year. Regression analysis was performed to determine whether age, gender, or BMI affected imaging choice.

Results: The study included a total of 2,108 patients, including 967 (43.5%) females and 599 (27%) children (<18 years old). CT use increased over time for the entire cohort (2.9% to 82.4%, $P < .0001$), and each subgroup (males, females, adults, children; $P < .0001$ for each). CT use increased more in females and adults than in males and children, but differences in trends were not statistically significant (male versus female, $P = .8$; adult versus child, $P = .1$). The percentage of patients who had no imaging used for the diagnosis of appendicitis decreased over time ($P < .0001$ overall and for each subgroup), and no difference was found in trends between complementary subgroups (male versus female, $P = .53$; adult versus child, $P = .66$). No statistically significant changes were found in use of ultrasound or MRI over the study period. With increasing BMI, CT was more frequently used.

Conclusions: Of those diagnosed with appendicitis at an academic medical center, CT use increased more than 20-fold. However, no statistically significant trend was found for increased use of ultrasound or MRI.

Key Words: Appendicitis, CT, MRI, ultrasound, resource utilization

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INTRODUCTION

Appendicitis is a common cause of abdominal pain in patients seen in the emergency department (ED); 267,585 cases were diagnosed in the United States in 2012 [1].

Historically, the diagnosis of appendicitis has been based on history and physical examination alone, but this is incorrect as much as 30% of the time [2]. Although clinical scoring systems such as the Alvarado score

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improve the risk stratification of patients with possible appendicitis, a “negative” score misses 13.3% of patients who have appendicitis [3]. A missed diagnosis of appendicitis can have important consequences, including rupture of the appendix, abscess formation, peritonitis, sepsis, and death.

The desire to prevent these outcomes is balanced by the physician goal of minimizing the negative laparotomy (appendectomy) rate (NLR) for those patients who are suspected of having appendicitis. Although this rate previously has been considered acceptable at 10%-20% [4], the diagnostic accuracy of medical imaging has dramatically lowered this acceptability threshold to less than 5%. As a result, the evaluation of patients who have symptoms of possible appendicitis frequently involves the use of cross-sectional imaging, particularly CT.

Although a few studies have documented no change in NLR when CT is used preoperatively [5], most have shown that the NLR for appendicitis is lowered substantially when CT imaging is used to confirm the diagnosis. For example, one study found that when no imaging was used, the NLR was 26.6%, compared with 6.6% with CT [6]. Another single-center study found that the NLR decreased from 23%, in 1990, to 1.7% in 2007, when a corresponding increase occurred in preoperative CT, from 1% to 97.5% of patients [7]. Moreover, use of CT allows for the diagnosis of other nonappendicitis pathologies. Pooler et al [8] found that for adults who were referred to the ED for evaluation of appendicitis, 23.6% were found to have appendicitis; another 31.6% had another alternative diagnosis, 41.1% of whom required hospitalization, and 22% of whom required a surgical intervention [8].

Less well documented is the effect of ultrasound and MRI on NLRs, although their use in the diagnosis of appendicitis is recommended in specific circumstances, particularly for children and pregnant women [9]. Given that the accuracy of ultrasound has been shown to be inferior to that of CT [10-12], its effect on NLRs may be lessened, compared with the effect of CT. For example, a state-level registry study showed that the NLR was 9.8% for patients who had no imaging, 8.1% for those who had an ultrasound, and 4.5% for those who had a CT scan [13]. Few studies have demonstrated the effect of MRI on NLR, although its accuracy for diagnosing appendicitis has been shown to be similar to that of CT [14-16]. One center found that the NLR for pregnant women dropped from 55% to 29% when MRI was introduced into the diagnostic pathway [17].

Although several studies have documented the increase over time in CT imaging utilization for ED patients with abdominal pain [18-21], these studies have not examined whether MRI or ultrasound utilization has increased. This issue is particularly significant, given the mounting attention given to potential harm from ionizing radiation associated with CT. Ionizing radiation is hypothesized to increase the lifetime risk of cancer by approximately one case for every 2,000 abdominal CT scans performed [22], although some have debated the severity of harm from CT [23]. Assuming that these theoretical projections are correct, as much as 1.5%-2% of all current cancers could be related to the use of CT scans [24]. Alternatively, MRI and ultrasound use no ionizing radiation, obviating this potential risk. Furthermore, the use of imaging in general has been suggested to be too high, with one study suggesting that 20% of appendicitis cases should be able to be diagnosed without any type of imaging test [25].

Currently, several recommendations outline appropriate use of imaging tests for the evaluation of right, lower-quadrant abdominal pain (ie, evaluating for appendicitis), including the ACR's Appropriateness Criteria[®] [26]. A combination of CT, ultrasound, and/or MRI is suggested, depending on patient characteristics and the pretest probability of appendicitis. However, the trend in imaging utilization among these modalities in a single population has not been reported previously. The aim of this study, therefore, is to characterize use of imaging tests for the diagnosis of appendicitis during a 22-year period at a large, academic, tertiary-care medical center. In addition, we aim to evaluate whether age group (age \geq 18 years versus $<$ 18 years), gender, or body mass index (BMI) may affect the imaging test used.

METHODS

Study Design and Setting

This is a HIPAA-compliant, retrospective study, approved by the institutional review board, of patients diagnosed with appendicitis at a single academic medical center in the US Midwest, with an annual ED census of approximately 50,000. The study includes data from patients seen in the ED between 1992 and 2014.

Selection of Participants

The hospital's billing database was used to identify patients with an International Classification of Disease—ninth edition (ICD-9) diagnosis code for appendicitis.

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