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Campaigns Against Ionizing Radiation and Changed Practice Patterns for Imaging Use in Pediatric Appendicitis

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Physicians strive to provide the best care for their patients, but defining the best care can be challenging. The diagnosis of pediatric appendicitis requires reconciling many factors often in conflict with one another. In this setting, imaging has taken on a prominent role. Computed tomography (CT) has higher sensitivity and specificity and is less operator dependent compared with ultrasonography (US).¹ Computed tomography is not without risk, however, because it uses ionizing radiation and requires an intravenous contrast load. At face value, CT imaging is more expensive than US or no imaging, but a missed diagnosis, negative appendectomy (the finding of a normal appendix at operation), admission for observation, or repeated imaging study also increases health care costs. Ultrasonography does not involve the risks of ionizing radiation or renal damage from intravenous contrast, but its lower accuracy may be associated with other risks, including a greater chance of a missed diagnosis or a negative appendectomy.¹ Two national campaigns, Image Gently and Choosing Wisely, have emerged that emphasize reducing the dose of radiation used in CT scans and eliminating unnecessary pediatric imaging studies.^{2,3} How have the competing agendas of ensuring an accurate diagnosis while managing cost and patient risk affected physician practices regarding imaging for pediatric appendicitis? In this issue, Bachur et al⁴ evaluate the changing trend of the use of imaging modalities in freestanding pediatric hospitals.

In their study, Bachur et al⁴ performed a retrospective review of the trends in the use of US and CT for the diagnosis of pediatric appendicitis. Using the Pediatric Health Information System (PHIS) database managed by the Children's Hospital Association, they examined 52 153 pediatric patients younger than 19 years with appendicitis and an encounter in the emergency department in 1 of 35 freestanding pediatric hospitals from 2010 through 2013. During the 4-year study period, the proportion of US examinations used in the diagnosis of appendicitis increased from 24.0% to 35.3%. In addition, the use of CT decreased from 21.4% to 11.6%. Despite the increase in the use of US and decrease in the use of CT, the proportion of negative appendectomies declined, and no change occurred in the proportion of children with appendiceal perforation, missed appendicitis, or serial US examinations.

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Bachur et al⁴ provide evidence that a decrease in CT and increase in US studies for the diagnosis of acute appendicitis at freestanding pediatric institutions has not resulted in a higher proportion of complications related to the potentially decreased sensitivity of US relative to CT.¹ The primary limitation of the data set is that 50% of children do not receive any imaging at the PHIS hospital of record. We cannot assume that these children underwent no imaging because observational studies that are designed to capture imaging use have found that more than 93% of children had preoperative imaging before appendectomy.^{5,6} Instead, patients without imaging recorded at the PHIS institution more likely underwent imaging at the referring hospital, most likely a CT scan based on what is known regarding patterns of imaging use from previous research.^{7,8} Analysis of the Healthcare Cost and Utilization Project Kids' Inpatient Database by Raval et al⁷ showed that 72.5% of pediatric patients undergoing evaluation at a general hospital had a CT, and Kotagal et al⁸ noted an 8-fold higher odds of CT use at a nonpediatric hospital. Pretransfer imaging is a source of ionizing radiation-based imaging and the potential need for repeated imaging after transfer. Although similar trends of increasing US and decreasing CT use have been noted at referring institutions, these changes are modest in degree relative to the use of imaging in freestanding pediatric hospitals, and patients seen at nonpediatric hospitals are still far more likely to undergo CT imaging.^{6,8}

This study is a follow-up to the earlier analysis by Bachur et al⁹ that used the same methods to examine imaging trends from 2005 through 2009, in which the authors noted similar trends. Three additional multi-institutional studies have examined trends in imaging for the diagnosis of pediatric appendicitis. Two cross-sectional studies used the National Hospital Ambulatory Medical Care Survey, an annual governmental survey of emergency departments in the United States, to evaluate imaging practices for the workup of abdominal pain.^{10,11} This nationally representative sample of emergency department visits showed that although the use of CT in the evaluation of abdominal pain significantly increased from 1998 through 2008 (from 0.9% to 15.4%), the use of US did not increase.¹¹ During this same period, neither study found a change in the number of children ultimately diagnosed as having appendicitis.^{10,11} Similar to the study by Bachur et al,⁹ Kotagal et al⁶ examined trends in imaging for the diagnosis of pediatric appendicitis, but they included pediatric and nonpediatric hospitals and used data from the Surgical Care and Outcomes Assessment Program (SCOAP) in Washington State. They found that the use of US as a first imaging modality significantly increased from 32.6% to 69% from 2008 through 2013, whereas the use of any CT decreased.⁶ However, even at the end of the study period, more than 40% of children still received a CT before ultimately undergoing appendectomy, often after a US study with nondiagnostic findings.⁶

These data suggest that the practice behavior of emergency medicine physicians and others involved in the care of pediatric patients who present with acute abdominal pain has shifted. These observational studies cannot show a causal relationship between this behavior and the dissemination of programs such as Image Gently and Choosing Wisely; however, the shift is likely related to a collective consciousness regarding the potential risks of ionizing radiation and the increasing costs of health care.^{2,3} Although US has been shown to be an acceptable alternative to CT, US is limited by the variation in the quality of the examination related to the experience of the operator.^{12–15} For low-volume referring institutions, a cost analysis

must be performed to evaluate the decision to transfer a child with suspected appendicitis without imaging, with a CT study, or with a US study with potentially inconclusive findings. The costs of patient transfer, including the burden on the family, must be weighed in relation to the risk and expense of CT imaging. Alternatively, ultrasonographers may need additional training or maintenance of certification if they do not perform a baseline number of examinations in a given period.

Pediatric abdominal pain and the subset of patients with appendicitis constitute a significant proportion of pediatric use of health care resources. The trends in imaging modalities used for the diagnosis of pediatric appendicitis are a litmus test for the changing values regarding patient safety and the cost of health care. The increasing use of US and decreasing use of CT without a demonstrated rise in perforated appendicitis, missed appendicitis, or negative appendectomies support the national message of avoiding the potentially harmful effects of ionizing radiation.

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