To CT or not to CT? The influence of computed tomography on the diagnosis of appendicitis in obese pediatric patients

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Podium presentation at the Canadian Surgery Forum, Vancouver, BC, Sept. 20, 2014

Accepted for publication Nov. 12, 2014

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DOI: 10.1503/cjs.009014

Background: Appendicitis is a common pediatric query. However, obesity often results in nondiagnostic ultrasounds and increased likelihood of abdominal computed tomography (CT). Concern regarding radiation exposure led the Canadian Association of Radiologists to recommend foregoing CT when ultrasounds are nondiagnostic and clinical suspicion is high. We evaluated this recommendation by quantifying the influence of CT on the diagnosis of pediatric appendicitis.

Methods: We performed a 2-year retrospective case series of children presenting with suspected appendicitis. We stratified patients by weight (obese v. nonobese) and pediatric appendicitis score (PAS) and examined how often they received abdominal CT, why they received it, and its influence on diagnosis.

Results: Of 223 patients (84 obese, 139 nonobese), 54 received CT. Obese patients received CTs more frequently than nonobese patients (29% v. 22%). The most common reason for CT was a nondiagnostic ultrasound (75% in obese, 80% in nonobese patients). Sixty-five percent of CTs obtained after nondiagnostic ultrasounds confirmed the initial diagnosis, but the rates were 80% and 50%, respectively, when only obese and only nonobese patients were considered. Obese patients were 4 times more likely to have a CT confirming their initial appendicitis diagnosis.

Conclusion: Because obese patients are more likely than nonobese patients to have a CT that confirms appendicitis, when treating an obese pediatric patient with suspected appendicitis and a nondiagnostic ultrasound, surgeons with a high clinical suspicion should strongly consider foregoing CT and proceeding with treatment.

Contexte : L'appendicite est un tableau fréquent en pédiatrie. Toutefois, l'obésité produit souvent des résultats non diagnostiques à l'échographie et accroît la probabilité de recours à la tomographie abdominale. L'inquiétude soulevée par l'exposition aux radiations a poussé l'Association canadienne des radiologistes à déconseiller la tomographie lorsque l'échographie se révèle non diagnostique et que les soupçons cliniques sont élevés. Nous avons évalué cette recommandation en quantifiant l'influence de la tomographie sur le diagnostic de l'appendicite chez l'enfant.

Méthodes : Nous avons procédé à la revue rétrospective d'une série de cas pédiatriques d'appendicite soupçonnée sur une période de 2 ans. Nous avons stratifié les patients selon le poids (obèses c. non obèses) et selon le score diagnostique d'appendicite pédiatrique, puis examiné la fréquence à laquelle on recourait à la tomographie abdominale, sa justification et son influence sur le diagnostic.

Résultats : Sur 223 patients (84 obèses, 139 non obèses), 54 ont subi une tomographie. Les patients obèses ont été soumis à la tomographie plus souvent que les patients non obèses (29 % c. 22 %). La raison la plus fréquemment invoquée pour recourir à la tomographie était l'échographie non diagnostique (75 % chez les patients obèses, 80 % chez les patients non obèses). Soixante-cinq pour cent des tomographies obtenues après une échographie non diagnostique ont confirmé le diagnostic initial, mais les taux étaient de 80 % et de 50 % respectivement lorsqu'on analysait les groupes obèses et non obèses séparément. Les patients obèses étaient 4 fois plus susceptibles de voir leur diagnostic initial d'appendicite confirmé par la tomographie.

Conclusion : Étant donné que les patients obèses sont plus susceptibles que les patients non obèses de subir une tomographie qui confirmerait une appendicite, face à un patient pédiatrique obèse chez qui l'on soupçonne une appendicite et dont les résultats à l'échographie sont non diagnostiques, les chirurgiens qui entretiennent des soupçons cliniques élevés devraient envisager fortement d'éviter la tomographie et de procéder au traitement.

Childhood obesity has reached epidemic proportions in Canada. According to the 2009–2011 Canadian Health Measures Survey, close to one-third of children aged 5–17 years (approximately 1.6 million children) were classified as overweight (19.8%) or obese (11.7%).[1] As the percentage of obese children increases, so too does the percentage of obese children visiting the emergency department (ED). Sivet[2] has demonstrated that appendicitis is the most common condition in children requiring emergency abdominal surgery and, therefore, one of the most commonly screened diseases in children presenting to the ED with abdominal pain. The rising rate of obesity among pediatric ED patients, combined with the frequency of appendicitis, presents a growing quandary for the managing physician. The morbidity and mortality associated with a perforated appendix leads the physician to vigilance in ruling out appendicitis, typically via history, physical examination and laboratory tests, followed by diagnostic imaging, typically in the form of ultrasonography. Unfortunately, obesity also constitutes an independent predictor for a nondiagnostic ultrasound.[3] This leads the surgeon to either treat the patient based on clinical findings or to order additional imaging, typically in the form of abdominal computed tomography (CT).

According to a recent Canadian study, these diagnostic difficulties result in obese children suspected of having appendicitis being 3 times more likely to receive abdominal CT than nonobese children.[4] Other than the increased rate of CT, the authors found no significant difference in outcomes between the 2 groups. As a result, they suggested that obese pediatric patients with suspected appendicitis and nondiagnostic ultrasounds should receive abdominal CT more frequently than nonobese patients.

While this recommendation appears logical based on the evidence, several issues make such a suggestion dubious in the absence of further evidence. The study did not quantify what contribution these CT scans made to patient diagnosis and management. It is difficult to truly evaluate the role of CT in the management of pediatric appendicitis in the absence of such data. This is especially true given the conclusions of 3 previous studies.[5–7] Two of them[5,6] argued that the increased use of CT among pediatric patients with appendicitis has not contributed substantially to a lower rate of negative appendectomies and may in fact increase perforation rates. The third study[7] argued that focused appendiceal CT does not increase the accuracy of diagnosis compared with history, physical examination and laboratory studies. Furthermore, the ionizing radiation delivered by abdominal CT has been increasingly identified as a contraindication for CT imaging in the pediatric population. According to one estimate, a single occurrence of abdominal CT in a child imparts a lifetime risk of radiation-induced cancer of 26.1 per 100 000 in girls and 20.4 per 100 000 in boys.[8] These potentially negative health outcomes led the Canadian Association of Radiologists to recommend that, when ultrasounds are nondiagnostic and clinical suspicion for appendicitis is high, surgeons consider treating without further imaging (i.e., CT).[9] These disparate claims necessitate that the influence of CT on the diagnosis of pediatric appendicitis be quantified so that informed management decisions can be made.

The influence of abdominal CT on the diagnosis and treatment of obese pediatric patients with suspected appendicitis is currently unknown. This information is important because it will allow surgeons to make better evidence-based decisions when considering the impact a CT scan may or may not have on a pediatric patient's diagnosis and management. One study conducted in an adult population[10] indicated that CT imaging rarely changed management in patients whose presentations were highly suspicious for appendicitis, but frequently changed management if the clinical diagnosis was indeterminate. However, this study did not include children, and did not differentiate based on weight, both of which are key determinants in the present discussion. A previous pediatric study[11] compared outcomes of obese and nonobese patients with appendicitis; however, this study examined outcomes only from patients who underwent appendectomy, did not include a focus on the role of CT in those outcomes and failed to use the most appropriate measurement for classifying obesity — body mass index (BMI) — when categorizing patients (instead, the study used standard deviations from mean weight for age).

We were therefore interested in accomplishing 2 main objectives with this study. The first was to quantify abdominal CT rates and purposes among both obese and nonobese pediatric patients with suspected appendicitis. After identifying which abdominal CT scans were ordered to confirm or rule out the preliminary clinical diagnosis of appendicitis, our second objective was to quantify and analyze the influence those scans had on the preliminary clinical diagnosis of appendicitis for both obese and nonobese pediatric patients.

Methods

We retrospectively analyzed the medical records of all children aged 18 years or younger who presented with appendicitis-like symptoms between Jan. 1, 2011, and Dec. 31, 2012, in the Saskatoon Health Region, Saskatoon, Saskatchewan.

In order to minimize selection bias, we established broad inclusion criteria so that every patient who was suspicious for appendicitis was eligible for inclusion. To be considered suspicious for appendicitis, a patient must have attained a pediatric appendicitis score (PAS)[12] of 5 or higher and either received diagnostic imaging in the form of ultrasonography or abdominal CT to rule out appendicitis (before discharge) or proceeded directly to surgery for exploratory laparotomy/appendectomy.

The PAS is a clinically validated and well-recognized system for categorizing the likelihood of a patient having appendicitis. (Box 1) By using the PAS in this study, we can define levels of clinical suspicion and demonstrate the validity of the requisite imaging. We used the PAS to stratify patients into low (≤ 4), intermediate (5–7), and high (≥ 8) clinical suspicion categories. These categories accord with those validated in a previous Canadian study that demonstrated a sensitivity of 97.6% for ruling out appendicitis in the low suspicion category and a specificity of 95.1% for ruling in appendicitis in the high suspicion category.[13]

We recorded and tabulated each patient's height, weight, age, sex, presenting history, physical examination findings, laboratory results, imaging studies, initial and final diagnosis, treatment and pathology report to determine how many patients received CT, why they received it and whether or not their CT scans confirmed or overturned the initial diagnosis of appendicitis. We also documented any patient's return to hospital with a confirmed appendicitis within 30 days of having appendicitis ruled out and being released (i.e., "missed" appendicitis).

We calculated each patient's BMI for age percentile (BMIFAP) using the Centers for Disease Control and Prevention electronic BMIFAP calculator and growth charts, which use the formula weight (kg)/height (m^2) and standardize the result for age and sex.[14] We considered children to be obese if they had a BMIFAP of 85 or higher or nonobese if they had a BMIFAP lower than 85. This range accords with previously published research.[4]

To accomplish the second objective of our study, it was important to include in the analysis only those abdominal CT scans whose purpose was to confirm or rule out the preliminary clinical diagnosis of appendicitis. Therefore, CT scans obtained as the initial imaging modality and those obtained as a follow-up to a nondiagnostic ultrasound were included in the data set. A nondiagnostic ultrasound was defined as one on which the appendix could not be visualized or one that produced equivocal findings. Abdominal CT scans ordered for the purpose of investigating an abscess, either identified on an ultrasound or suspected clinically, were excluded from this data set. We also excluded CT scans that were obtained for another purpose but revealed an incidental appendicitis. All imaging diagnoses were based on the final radiology report, and all final diagnoses were based on the official pathology report from the patients' health records.

Statistical analysis

We analyzed differences in why patients received CT scans using the χ^2 test. We calculated the measure of CT influence on the initial diagnosis of the entire patient population based on the normal approximation to the binomial. The likelihood of obese and nonobese pediatric patients undergoing abdominal CT and the likelihood of CT scans changing the initial diagnosis of appendicitis in obese and nonobese patients were calculated by means of an odds ratio (OR). We considered results to be significant at $p < 0.05$. We conducted all statistical assessments using SPSS software version 20.0 (SPSS Inc.).

Results

A total of 223 patients were included in this 2-year retrospective review, 84 (38%) of whom were obese and 139 (62%) of whom were nonobese. In all, 54 (24%) patients received abdominal CT in order to further investigate the suspected clinical diagnosis of appendicitis. The demographic and clinical characteristics of the study sample are summarized in Table 1. The age distribution was almost identical between obese and nonobese patients (12.1 ± 3.9 yr v. 12.5 ± 4.0 yr). The sex distribution was equal in the nonobese group (49% girls v. 51% boys); however, most patients in the obese group (65.5%) were boys.

Box 1. Diagnostic indicators and their score values

Anorexia	1
Pyrexia	1
Nausea/emesis	1
Cough/percussion/hip tenderness	2
Tenderness in right lower quadrant	2
Migration of pain	1
Leukocytosis > 10 000 cells/mm^3	1
Polymorphonuclear neutrophilia > 7500 cells/mm3	1
Total	10

Table 1. Demographic and clinical characteristics of study sample

Characteristic	Group; no. (%) or mean ± SD — Total sample (*n* = 223)	Nonobese (*n* = 139)	Obese (*n* = 84)
Age, yr	12.4 ± 4.0	12.5 ± 4.0	12.1 ± 3.9
BMIFAP	65.8 ± 28.4	49.1 ± 23.3	93.4 ± 4.3
Female sex	97 (43.5)	68 (49)	29 (34.5)
Male sex	126 (56.5)	71 (51)	55 (65.5)
Received ultrasound	205 (91.9)	127 (91.3)	78 (92.9)
Proceeded to surgery without imaging	13 (5.8)	8 (5.8)	5 (6.0)
Received CT	54 (24.2)	30 (21.6)	24 (28.6)
Age, yr	12.7 ± 3.99	13.1 ± 4.1	12.3 ± 3.9
BMIFAP	69.8 ± 28.1	48.4 ± 22	94 ± 4.0
Female sex	23 (43)	14 (61)	9 (39)
Male sex	31 (57)	16 (52)	15 (48)

BMIFAP = body mass index for age percentile; CT = computed tomography; SD = standard deviation.

Of the 223 patients included in the study, 91.9% received abdominal ultrasonography. Of those who did not, 5.4% proceeded directly to surgery without any imaging, and the remaining 2.7% received abdominal CT instead of ultrasonography. Proportionally more obese patients received CT than nonobese patients (28.6% v. 21.6%). The odds of an obese child in our study receiving abdominal CT to investigate and manage possible appendicitis were 1.5 times higher than the odds for a nonobese child (95% CI 0.77–2.9, p = 0.23).

Figures 1 and 2 demonstrate the different reasons why obese and nonobese pediatric patients with possible appendicitis received abdominal CT. The most common reason for CT was nondiagnostic ultrasound (75% of obese and 80% of nonobese patients) followed by investigation for possible abdominal abscess (17% of obese and 20% of nonobese patients). Five of the 10 abdominal CT scans ordered for abscess investigation were in follow-up exams to a previous ultrasound (3 obese patients and 2 nonobese patients), while the other 5 were ordered as the initial imaging modality (1 obese patient and 4 nonobese patients). The calculated percentages were nearly identical in every category given, except body habitus. There were no significant differences in reasons for obtaining scans between the 2 groups.

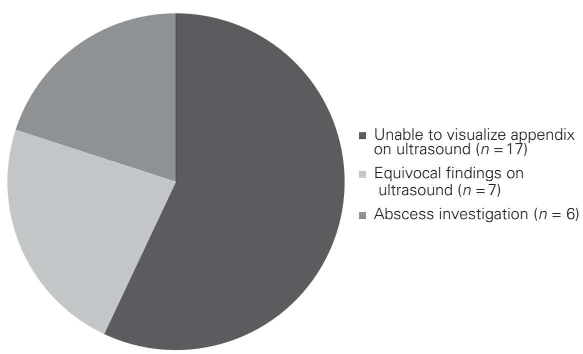

Fig. 1. Explanations for why nonobese pediatric patients with possible appendicitis received abdominal computed tomography (n = 30).

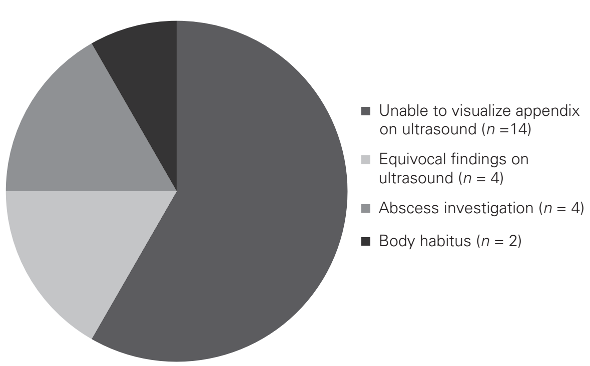

Fig. 2. Explanations for why obese pediatric patients with possible appendicitis received abdominal computed tomography (n = 24).

Figure 3 illustrates the influence of abdominal CT scans on the initial diagnoses of patients in this study. When we viewed the study population as a whole, we found that abdominal CT performed to confirm or rule out a preliminary diagnosis of appendicitis confirmed the diagnosis 65% of the time (95% CI 50%–78%; p < 0.001). However, when we stratified the results based on BMIFAP, we found that a much larger proportion of obese patients had their initial diagnoses of appendicitis confirmed rather than overturned via abdominal CT scan (80% v. 20%) than did nonobese patients (50% v. 50%). Therefore, the odds of an abdominal CT scan that was obtained to confirm an initial clinical diagnosis of appendicitis changing that diagnosis was 75% lower in obese patients than in nonobese patients (OR 0.25, 95% CI 0.06–0.97, p = 0.039). In other words, obese patients were 4 times more likely than nonobese patients to have an abdominal CT that confirmed the initial diagnosis of appendicitis (OR 4.0, 95% CI 1.03–15.5, p = 0.039).

Table 2 delineates the PAS of patients receiving abdominal CT to investigate a preliminary clinical diagnosis of appendicitis. The average score for obese patients was 7.9, and 75% of the obese patients scanned were in the high suspicion category (mean PAS 8.2). Of those highly suspicious patients, 93% had their initial diagnoses confirmed

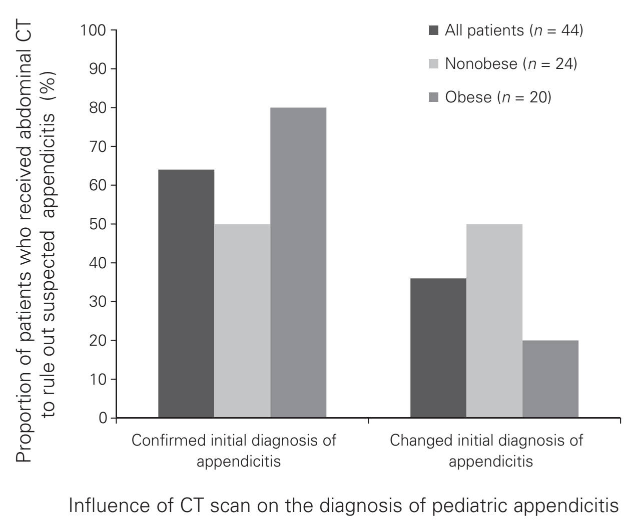

Fig. 3. The influence of abdominal computed tomography (CT) on the initial clinical diagnosis of pediatric patients presenting with possible appendicitis.

by the CT scan. Most obese patients whose diagnoses were changed (75%) came from the intermediate suspicion group (mean PAS 6.8). The average PAS for nonobese patients receiving CT was comparatively lower (6.4), with 67% of those patients falling into the intermediate suspicion category. All of the nonobese patients whose CT scans ruled out appendicitis were from the intermediate suspicion category (mean PAS 5.3), while 75% of those whose scans confirmed appendicitis were from the high suspicion category. All of the CT scans included in this study were warranted according to the previously mentioned PAS criteria of suspicion.

Appendicitis was missed in only 1 patient who received CT: an obese patient with an intermediate PAS whose CT scan ruled out appendicitis but who went on to exploratory laparotomy and positive appendectomy. There were no negative appendectomies among patients who received CT, those who received both ultrasonography and CT and those who proceeded to surgery with no imaging. The negative appendectomy rate for those who received ultrasonography alone was 3.2%.

Discussion

We discovered that 24% of children presenting to the ED with appendicitis-like symptoms received abdominal CT and that a greater proportion of those patients were obese than nonobese (28.6% v. 21.6%). Thus, in our study, obese pediatric patients with suspected appendicitis were 1.5 times more likely than nonobese patients to receive abdominal CT. Although this finding did not reach statistical significance, likely owing to a small sample size, it is in accordance with similar findings from another recent study from a major Canadian centre.[4] That study indicated obese pediatric patients with appendicitis were up to 3 times more likely to receive abdominal CT than nonobese patients, a claim that was statistically significant. This finding indicates that increased rates of abdominal CT in obese pediatric patients with appendicitis are likely a trend across Canada that should be observed more closely. Furthermore, the purposes of the CT studies across obese and nonobese populations did not vary significantly, with nondiagnostic ultrasounds being by far the most common reason for CT in both subgroups. Based on these results, there is no significant evidence to claim that obese pediatric patients with suspected appendicitis receive abdominal CT for different reasons than nonobese patients. Rather, it appears that, because obese patients are more likely to have nondiagnostic ultrasounds, they are also more likely to undergo abdominal CT.

The second major objective of our study was to quantify and analyze the influence of abdominal CT, ordered to confirm the preliminary clinical diagnosis of appendicitis, on that diagnosis for both the obese and nonobese patient subgroups. These abdominal CT scans confirmed the diagnosis 65% of the time in the total sample. However, a greater proportion of obese patients had their initial diagnoses of appendicitis confirmed via abdominal CT scan than overturned (80% v. 20%); this was not the case for nonobese patients, in whom the diagnoses were confirmed via abdominal CT half of the time (50% v. 50%). Obese patients in our study were 4 times more likely than nonobese patients to have an abdominal CT scan that confirmed their initial clinical diagnosis of appendicitis.

When we analyze these results in conjunction with each patient's respective PAS, we can observe a plausible explanation for these findings and better appreciate their diagnostic import. Most obese patients with a nondiagnostic ultrasound who proceeded to follow-up CT had a higher PAS than nonobese patients who followed the same course (7.9 v. 6.4). In total, 75% of obese patients with nondiagnostic ultrasounds had a PAS of 8 or higher compared with only 33% of nonobese patients. This contrast can likely be explained by obese pediatric patients more frequently having nondiagnostic ultrasounds despite the presence of a truly inflamed appendix owing to their body habitus. In contrast, nonobese patients are likely have nondiagnostic ultrasounds more often owing to a pathology other than an inflamed appendix. As a result, both patient groups proceed to further imaging, where abdominal CT scans are more apt to identify the true pathology, either appendiceal in origin or otherwise. The fact that, despite their nondiagnostic ultrasounds, most patients in the high suspicion group had their initial diagnoses confirmed by CT scan

Table 2. Pediatric appendicitis scores for patients receiving abdominal computed tomography to diagnose possible appendicitis

	Pediatric appendicitis scores						
Group	5	6	7	8	9	10	Mean ± SD
Obese (*n* = 20)	1	1	3	9	6	—	7.9 ± 1.1
Diagnosis confirmed	—	1	1	8	6	—	8.2 ± 0.8
Diagnosis changed	1	—	2	1	—	—	6.8 ± 1.3
Nonobese (*n* = 24)	10	5	1	6	2	—	6.4 ± 1.5
Diagnosis confirmed	1	3	—	6	2	—	7.4 ±1.3
Diagnosis changed	9	2	1	—	—	—	5.3 ± 0.7

SD = standard deviation.

(93% in the obese group and 100% in the nonobese group) further bolsters this claim as does the fact that there were no negative appendectomies among patients who had surgery after CT confirmed appendicitis.

The seemingly high rate of CT scans ruling out appendicitis in nonobese patients compared with obese patients can likely be attributed to the fact that more patients in the nonobese group fell into the intermediate suspicion category and had nondiagnostic ultrasounds because of a disease process other than appendicitis. A period of clinical evaluation following a nondiagnostic ultrasound in a nonobese patient or repeat ultrasonography may give the physician more cause to avoid potentially unnecessary abdominal CT in this patient population.

We know that the sensitivity and specificity of abdominal CT for investigating appendicitis in children is excellent (96% and 97%, respectively), regardless of BMIFAP.[15] We can conclude from our data and those from other studies that appendicitis can be identified correctly on an abdominal CT scan in most pediatric patients. Since the initial clinical diagnosis of appendicitis was confirmed by abdominal CT only 65% of the time in our study, the decision to surgically manage each of the patients who received CT without the input from that scan would have resulted in an approximate negative appendectomy rate of 35%, which is much higher than the established norms (which can be just over 20%).[16] Therefore, surgeons should continue to order abdominal CT judiciously based on their level of clinical suspicion in order to maintain low negative appendectomy rates. However, in so doing, surgeons should recognize that obese pediatric patients are 4 times more likely than nonobese patients to have a diagnostic abdominal CT scan that confirms the clinical suspicion of appendicitis. The reason for this is most likely that obese patients are more prone to nondiagnostic ultrasounds than nonobese patients owing to increased body habitus. Therefore, a proportionally greater number of obese patients with true appendicitis end up receiving CT. As a result, surgeons should be more apt to maintain confidence in their clinical diagnoses in the face of nondiagnostic ultrasounds in obese pediatric patients, particularly if their clinical suspicion is high. Using a clinically validated classification system, such as the PAS, in the evaluation of suspected appendicitis would help to objectively categorize patients and lead to more accurate and timely diagnoses, while also limiting potentially unnecessary diagnostic imaging. In addition, following a nondiagnostic ultrasound, surgeons may consider a continued period of clinical observation, repeat ultrasonography, or low-dose, focused CT to limit the potential damages due to radiation.

If we follow the recommendation of Sulowski and colleagues[4] that obese pediatric patients with suspected appendicitis receive abdominal CT more often than their nonobese counterparts, we will expose a greater number of obese children to potentially harmful ionizing radiation (at necessarily higher radiation doses than their nonobese counterparts), with the result of simply confirming an initial diagnosis of appendicitis most of the time. Rather, the evidence from this study indicates that obese pediatric patients with a high clinical suspicion of appendicitis should receive diagnostic abdominal CT less often. Therefore, when treating an obese pediatric patient with suspected appendicitis and a nondiagnostic ultrasound, surgeons with a high clinical suspicion of appendicitis should not be easily dissuaded by the ultrasonography results. Rather, they should trust their clinical suspicion and strongly consider foregoing abdominal CT and proceeding with treatment. Should their suspicion for appendicitis fit the PAS intermediate criteria, they should give further thought to clinical re-evaluation of the patient before proceeding with imaging. Our results are likely generalizable to any large centre with a pediatric ED, trained and qualified staff and the availability of ultrasonography and CT technology.

Limitations

Our study was retrospective and included a relatively small sample size from which to draw conclusions. Furthermore, the retrospective nature of this study puts certain limitations on the data set and conclusions that derive from it. The fact that physicians were not intentionally recording PAS results in the patients' records could have led to a certain margin of error in tabulating the results. Some data may have been omitted from the patients' records that would have changed the category to which they belonged. The line between categories may therefore be more blurry than it would have been in a prospective study. Finally, our results are quite contingent on the level of training and proficiency of the staff involved in acquiring and interpreting the diagnostic imaging findings.

Conclusion

Obese pediatric patients presenting to the ED with appendicitis-like symptoms are 1.5 times more likely than nonobese pediatric patients to receive abdominal CT and 4 times more likely than nonobese patients to have a CT scan that confirms the initial diagnosis of appendicitis. These results argue that strong consideration be given to forgoing abdominal CT and proceeding directly to treatment in an obese pediatric patient with a high clinical suspicion for appendicitis and a nondiagnostic ultrasound.

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Competing interests: None declared.

Contributors: Both authors designed the study and analyzed the data, which H. Roy acquired. H. Roy wrote the article, which both authors reviewed and approved for publication.

References

1. Roberts K, Shields M, de Groh M, et al. Overweight and obesity in children and adolescents: results from the 2009 to 2011 Canadian Health Measures Survey. *Health Reports* 2012;23(3). Available: www.statcan.gc.ca/pub/82-003-x/2012003/article/11706-eng.htm (accessed 2014 May 1).
2. Sivit CJ. Imaging the child with right lower quadrant pain and suspected appendicitis: current concepts. *Pediatr Radiol* 2004;34:447.
3. Schuh S, Man C, Cheng A, et al. Predictors of non-diagnostic ultrasound scanning in children with suspected appendicitis. *J Pediatr* 2011;158:112-8.
4. Sulowski C, Doria AS, Langer JC, et al. Clinical outcomes in obese and normal-weight children undergoing ultrasound for suspected appendicitis. *Acad Emerg Med* 2011;18:167-73.
5. Martin AE, Vollman D, Adler B, et al. CT scans may not reduce the negative appendectomy rate in children. *J Pediatr Surg* 2004;39:886-90.
6. Partrick DA, Janik JE, Janik JS, et al. Increased CT scan utilization does not improve the diagnostic accuracy of appendicitis in children. *J Pediatr Surg* 2003;38:659-62.
7. Stephen AE, Segev DL, Ryan DP, et al. The diagnosis of acute appendicitis in a pediatric population: to CT or not to CT. *J Pediatr Surg* 2003;38:367-71.
8. Doria AS. Optimizing the role of imaging in appendicitis. *Pediatr Radiol* 2009;39(Suppl 2):S144-8.
9. The 2012 CAR diagnostic imaging referral guidelines: Pediatrics. The Canadian Association of Radiologists: Ottawa (ON). Available: www.car.ca/en/standards-guidelines/guidelines.aspx (accessed 2014 May 1).
10. Santos DA, Manunga J, Hohman D, et al. How often does computed tomography change the management of acute appendicitis? *Am Surg* 2009;75:918-21.
11. Davies DA, Yanchar NL. Appendicitis in the obese child. *J Pediatr Surg* 2007;42:857-61.
12. Samuel M. Pediatric appendicitis score. *J Pediatr Surg* 2002;37:877-81.
13. Bhatt M, Joseph L, Ducharme F. Prospective evaluation of the pediatric appendicitis score in a Canadian pediatric emergency department. *Acad Emerg Med* 2009;16:591-6.
14. BMI percentile calculator for child and teen. Centers for Disease Control and Prevention: Atlanta (GA). Available: http://apps.nccd.cdc.gov/dnpabmi/ (accessed 2014 May 1).
15. Abo A, Shannon M, Taylor G, et al. The influence of body mass index on the accuracy of ultrasound and computed tomography in diagnosing appendicitis in children. *Pediatr Emerg Care* 2011;27:731-6.
16. Oyetunji TA, Ong'uti S, Bolorunduro O, et al. Pediatric negative appendectomy rate: trend, predictors, and differentials. *J Surg Res* 2012;173:16-20.