American Journal of Emergency Medicine (2007) **25**, 489–493

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The American Journal of Emergency Medicine

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Original Contribution

The use of the clinical scoring system by Alvarado in the decision to perform computed tomography for acute appendicitis in the ED☆

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Received 24 July 2006; accepted 13 August 2006

Abstract

Study Objective: Appendicitis is part of the differential of an acute abdomen and can be a difficult diagnosis to make. Strategies to suggest which patients presenting to the emergency department (ED) should undergo computed tomography (CT) scan to confirm appendicitis have not been addressed. We develop guidelines for CT scanning based on Alvarado clinical scores for patients with suspected and confirmed cases of appendicitis.

Methods: A retrospective review of 150 charts of patients aged 7 and older who presented with abdominal pain to the ED of a 392-bed acute care facility over a 6-month period were evaluated by ED physicians and underwent CT to rule out appendicitis. Patient demographics, presenting signs, and symptoms were documented. Using the scoring system for appendicitis, developed by Alvarado, each chart was retrospectively scored. The Alvarado scores were correlated with positive pathology findings, as well as Alvarado scores with a negative CT scan. Equivocal scores, having neither high sensitivity nor specificity for appendicitis were calculated.

Results: Computed tomography scans with Alvarado scores of 3 or lower were performed in 37% (55/150) of patients to rule out appendicitis. The sensitivity of Alvarado scores 3 or lower for not having appendicitis was 96.2% (53/55), and the specificity 67% (2/3). Patients with Alvarado scores 7 or higher had an incidence of acute appendicitis of 77.7% (28/36). The sensitivity of Alvarado scores 7 or higher for appendicitis was 77% (28/36), and the specificity 100% (8/8). The sensitivity of equivocal Alvarado scores, defined as scores of 4 to 6, for acute appendicitis was 35.6% (21/59), and the specificity 94% (36/38). The sensitivity and specificity of CT scans in patients with equivocal Alvarado scores remained high, at 90.4% and 95%, respectively.

Conclusions: In the equivocal clinical presentation of appendicitis as defined by Alvarado scores of 4 to 6, adjunctive CT is recommended to confirm the diagnosis in the ED setting. If clinical presentation suggests acute appendicitis by an Alvarado score of 7 or higher, surgical consultation is recommended. Computed tomography is not indicated in patients with Alvarado scores of 3 or lower to diagnose acute appendicitis.

☆ The article did not receive any financial support and has no conflict of interest.
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doi:10.1016/j.ajem.2006.08.020

1. Introduction

Abdominal pain is one of the most frequent presentations to the emergency department (ED). Appendicitis is part of the differential of an acute abdomen and can be a difficult diagnosis to make. Physical examination, laboratory or radiographic investigations, clinical suspicion, and experience can lead to the diagnosis.

A number of clinical scores have been developed attempting to decrease the false-positive rates of appendectomies [1-5]. These have been applied to inpatient surgical populations but not to the outpatient ED setting. Many variables have been incorporated in clinical scoring systems, but these have not altered the sensitivity and specificity of clinical examination [6,7].

Computed tomography (CT) has been advocated to diagnose acute appendicitis and further decrease the incidence of normal appendectomies [4,8,9]. Computed tomography scans demonstrate specific changes attributable to acute appendicitis [10,11] but may also have nonspecific findings [10]. The use of CT scan has decreased the negative appendectomy rate (NAR) to under 10% [6-9,12]. Computed tomography is used in the ED setting as an adjunct to a clinical examination, attempting to increase the accuracy of the diagnosis of acute appendicitis [8]. The use of CT may increase ED length of stay [6,12,13], expose patients to potentially harmful radiation [14], and possibly adds to the overall cost of the ED visit [15]. The challenge to the ED physician is to delineate which patient population is best served by a CT to rule out appendicitis. Presently, there are no published strategies to suggest which patients should undergo CT scan to confirm appendicitis despite the repeated call for guidelines [6,16-20]. In this review, we develop guidelines for CT scanning based on Alvarado clinical scores for patients with suspected and confirmed cases of appendicitis who have undergone CT scans.

2. Materials and methods

To establish CT ordering patterns, a retrospective review of charts was undertaken at a 392-bed acute care facility in northwestern Pennsylvania from February 1, 2004 through July 1, 2004. Patients aged 7 and older who presented to the ED with abdominal pain were evaluated by ED physicians and underwent subsequent CT to rule out appendicitis. The chart was excluded if CT scan was ordered by a surgeon during a consultation or by a family practitioner as an outpatient examination. All appendectomies for the same period were reviewed to ensure no patients who had an initial negative CT were lost to follow-up. A total of 150 patient charts were reviewed that met inclusion criteria.

Patient demographics, presenting signs, and symptoms were documented. There were 6 patient symptoms, 4 signs, and 2 laboratory indicators of appendicitis recorded, in keeping with the Alvarado score for appendicitis (Table 1). Patient symptoms included nausea, vomiting, migratory pain, anorexia, and right lower quadrant (RLQ) pain. Clinical signs included temperature, rebound tenderness, guarding, and RLQ tenderness. Laboratory values included white blood cell count and left shift on differential. Computed tomography findings, surgical findings, and pathology results were recorded for each patient, as indicated. Nonappendiceal findings were documented for all negative CT scans. The sensitivity and specificity of all CT scans were calculated based on pathology results of appendectomy.

The radiology department performs a uniform scanning protocol to rule out appendicitis. Approximately 30 minutes before scanning, 450 mL RediCat (Lafayette Pharmaceuticals, Lafayette, Ind) was administered to the patient parentally, followed by 100 mL OptiRay contrast (Mallinckrodt, Inc, St. Louis, Mo) via intravenous route, and 50 to 100 mL Hypaque contrast rectally (Amersham Health, Milwaukee, MI), depending on patient tolerance, immediately before CT procurement. Patients were scanned with either a GE Light Speed (GE Healthcare, Milwaukee, Mich) or GE High Speed scanner (GE Healthcare) with approximately 1-mm sections in accordance with standard radiographic regimens to rule out appendicitis. All radiographic images were interpreted by board-certified, experienced radiologists.

Using the scoring system for appendicitis, developed by Alvarado, each chart was retrospectively scored (Table 1) [1]. The Alvarado score was then compared with both CT and pathology results. The incidence of patients with acute appendicitis according to Alvarado scores was defined based on pathology. Patients with a high probability of acute appendicitis were predicted to have high Alvarado scores; a low likelihood of appendicitis predicted to have low scores. Equivocal scores were least predictive of appendicitis.

The sensitivity and specificity of the Alvarado scoring system were calculated for all scores. Using descriptive statistics, the Alvarado scores that correlated with positive pathology findings were determined, as well as Alvarado scores likely to correlate with negative pathology results. Equivocal scores having neither high sensitivity nor specificity for appendicitis were also calculated.

3. Results

A total of 99 negative and 51 positive CT scans for appendicitis were performed during the study period. There

Table 1 The Alvarado scoring system

	Mnemonic (MANTRELS)	Value
Symptoms	Migration	1
	Anorexia-acetone	1
	Nausea-vomiting	1
Signs	Tenderness in RLQ	2
	Rebound pain	1
	Elevation of temperature >37.3°C	1
Laboratory	Leukocytosis	2
	Shift to the left	1
Total Score		10

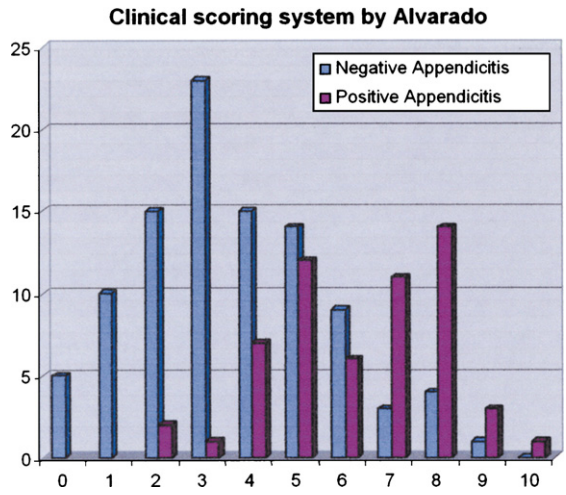

Fig. 1 Alvarado scores of patients with and without appendicitis.

were 3 false-negative and 3 false positive CT scans identified, leaving 51 patients with acute appendicitis (Fig. 1). The 3 false-positive CT scans led to 3 negative appendectomies for a NAR of 5.5% (3/54). In all patients, CT demonstrated a sensitivity of 94%, a specificity of 97%, and an overall accuracy of 96%.

A total of 58 females and 41 males underwent CT scans that were negative for appendicitis, including 3 false-negative scans. The average Alvarado score for patients without appendicitis (n = 96) was 3.57 (range, 0-9). Multiple alternative diagnoses were made by CT in the absence of acute appendicitis. The differential diagnosis of patients with negative scans included gastrointestinal, gynecological, urologic miscellaneous conditions, and negative scans (Table 2). Higher Alvarado scores were found with inflammatory conditions, such as diverticulitis or active pelvic inflammatory disease.

A total of 54 patients underwent CT scans that were positive for appendicitis, including 3 false-positive scans (Table 3). The average score for patients with appendicitis confirmed by pathology (n = 51) was 6.43 (range, 2-10). The 3 false-positive scans had Alvarado scores of 2, 4, and 6.

Choosing an Alvarado score of 4 or lower to not scan patients to rule out appendicitis yielded 7 (9.5%,7/73) delayed diagnoses of appendicitis. Choosing an Alvarado score of 3 or lower to not scan patients for appendicitis only yielded 2 (3.6%, 2/55) delayed diagnoses of appendicitis, and most (94.5%, 52/55) scans were negative. The accuracy of an Alvarado score 4 or lower in diagnosing a healthy appendix was 89% (65/73), for scores of 3 or lower, it was 96% (53/55). Therefore, Alvarado score 3 or lower was felt to be an acceptable score to not scan patients for appendicitis.

Computed tomography scans with Alvarado scores of 3 or lower were performed in 37% (55/150) of patients to rule out appendicitis. A total of 37 female and 18 male patients had Alvarado scores of 3 or lower. Of patients with scores 3 or lower, 96% (53/55) did not have appendicitis. The diagnostic accuracy of Alvarado scores 3 or lower in diagnosing a healthy appendix was 96.2% (53/55), and the specificity 67% (2/3). Only 2 male patients with Alvarado scores 3 or lower had a positive CT and were found to have appendicitis at pathology (Table 3). There was 1 male patient with false-positive CT who underwent appendectomy with an Alvarado score of 2.

Choosing an Alvarado score of 6 or higher for surgical consultation before CT scanning yielded a sensitivity for appendicitis of only 59.5% (25/42). Alternatively, an Alvarado score of 7 or higher yielded a sensitivity of 75% (27/36); Alvarado score 8 or higher demonstrated sensitivity of 76% (16/21). Therefore, an Alvarado score 7 or higher was felt to be a reasonable score for surgical consultation before CT scanning for appendicitis.

Patients with Alvarado scores 7 or higher had an incidence of acute appendicitis of 77.7% (28/36). A total of 13 females and 15 males with Alvarado scores greater than 7 underwent CT scans that were positive for appendicitis. The sensitivity of Alvarado scores 7 or higher for appendicitis was 77% (28/36), and the specificity, 100% (8/8). One male patient had a false-negative CT scan with Alvarado score of 7. Only 22.2% (8/36) of patients with Alvarado score higher than 7 had negative CT scans for appendicitis, representing 8.3% (8/96) of all negative scans. Of these, 2 were diagnosed with ovarian cysts, 2 demonstrated inflammatory bowel disease, 1 a small bowel obstruction, and 1 acute gangrenous cholecystitis. One CT was negative and one demonstrated nonspecific inflammatory changes.

Eliminating Alvarado scores 3 or lower and 7 or higher defined equivocal Alvarado scores as patients presenting with Alvarado scores of 4 to 6. During the study period, 59 CT scans were performed on patients with equivocal Alvarado scores of 4 to 6, including 36 females and 23 males. Of these, 61% (36/59) were negative and 32.2% (19/59) positive for appendicitis. The sensitivity of Alvarado scores 4 to 6 for acute appendicitis was 35.6% (21/59), and specificity 94% (36/38). The sensitivity and specificity of CT scans in patients with equivocal Alvarado scores remained high, at 90.4% and 95%, respectively.

Table 2 Patients without appendicitis

Alternative diagnosis	Alvarado score		
	0-3	4-6	7-10
	n = 52	n = 36	n = 8
Gynecologic	25% (13/52))	11.1% (4/36)	25% (2/8)
Gastrointestinal	1.2% (10/52)	19.4% (7/36)	50% (4/8)
Urologic	5.7% (3/52)	5.5% (2/36)	0
Miscellaneous	13.4% (7/52)	30.5% (11/36)	12.5% (1/8)
Negative	36.5% (19/52)	33.3% (12/36)	12.5% (1/8)
Total	54% (52/96)	38% (36/96)	8% (8/96)

Table 3 Patients with acute appendicitis

	Alvarado score		
	0-3	4-6	7-10
	n = 2	n = 19	n = 27
Male	3.9% (2/51)	13.7% (7/51)[a]	25.4% (13/51)[a]
Female	0	27.4% (14/51)[a]	29.4% (15/51)
Total	3.9% (2/51)	37.2% (21/51)	52.9% (28/51)

[a] Includes one false negative CT scan.

A higher Alvarado score correlated with an increased incidence of perforation at surgery. There were a total of 6 perforations in the study group, with scores of 7 (1/6), 8 (2/6), and 9 (3/6), respectively, with an average score of 8.3. The overall perforation rate was 11.7% (6/51).

4. Discussion

The Alvarado score was developed before the availability of CT in most ED settings. He described a clinical scoring system to differentiate patients in need of surgical intervention, attempting to decrease delayed or normal appendectomies (NAR) [1]. Using his 10-point score (Table 1), he found retrospectively reviewed surgical patients with a score 7 or higher had a 93% (184/197) chance of having acute appendicitis. In our cohort studied in the outpatient ED setting, we found sensitivity of score higher than 7 for appendicitis to be 77%. Before CT availability, Alvarado concluded that a score of 6 was safer, yielding a NAR of 8.7% (24/227) and few delayed appendectomies (5.8%, 16/227). Ten years later, Ohmann et al [2] validated the Alvarado score, finding it to have a sensitivity of 64% and specificity of 84%, which were superior to the scores of Christian and Christian [5] and Fenyo et al [4]. Ramirez and Deus [21] developed a prospective clinical score with independently weighted variables, describing a sensitivity and specificity of 80% and 81%, respectively, in the diagnosis of acute appendicitis. Fenyo et al [4] reported a scoring system with a sensitivity of 73%, a specificity of 87%, ad NAR of 17.5% overall, without adjunctive use of CT. Van den Broek [3] used a very simple score weighted heavily for male patients, and also without the adjunctive use of CT. He reported a sensitivity of 93% for acute appendicitis, specificity of 83%, and NAR of 7%. The addition of further variables to a scoring system does not alter the overall sensitivity, specificity, or accuracy of results [3,6,7,12,22]. The Alvarado score alone was validated independently to predict appendicitis [2,6].

Computed tomography scan for appendicitis is a helpful adjunctive test when appendicitis is a diagnostic consideration. Rhea et al [8] found the sensitivity and specificity of CT scan in a population of patients with suspected appendicitis to be 99% and 95%, respectively. In prospective clinical trials of surgical patients, the reported sensitivity of CT was well over 90% and specificity over 95% [6,7,9]. Rao et al [23] reported the sensitivity and specificity of CT for appendicitis of 100% and 97%, respectively, in the population of females of reproductive age.

In other clinical trials in the inpatient surgical setting, the use of CT has not been shown to surpass clinical judgment. Rhea et al [8] reported 12% (90/753) of patients taken to or without preoperative use of CT with a NAR of 5.6% in this group. Hong et al [6] used the Alvarado score to compare accuracy of clinical examination to CT in patients with acute appendicitis. He found the accuracy of clinical exam to be 92% (72/78) and that of CT to be 90% (61/68) and therefore no advantage to using CT in a population of surgical patients. Smink et al [7] concluded that clinical practice guidelines by surgeons in conjunction with CT were highly accurate in making the diagnosis of acute appendicitis in children, but that the liberal use of CT did not improve the accuracy of the diagnosis. Garfield et al [12] studied 124 surgical patients presenting with an equivocal clinical examination for acute appendicitis and found imaging did not change the perforation rate or the NAR.

Females of reproductive age are a notoriously difficult group to differentiate appendicitis from gynecologic pathologies. The routine use of CT to diagnose appendicitis in women of childbearing age has been repeatedly recommended [23-25]. The NAR of 12% in reproductive females has been reported in studies with an overall NAR of 2% [9]. In our study, females of reproductive age had a NAR of 2.2% (1/44). Gynecologic diagnoses by CT comprised 31.6% (19/60) of females without appendicitis, consistent with previous reports of the ability of CT to differentiate gynecologic diagnoses [23]. Patients presenting with equivocal Alvarado scores were commonly female (61%, 36/59).

During the same period, 5 appendectomies were performed without adjunctive CT and therefore did not meet inclusion criteria. They presented with Alvarado scores of 7 (2/5), 8 (2/5), and 9 (1/5), respectively. Of these, all were acute by pathology, one (Alvarado score of 7) perforated. All patients were male.

By correlating the Alvarado scores with the findings of CT done for suspicion of acute appendicitis, a trend was identified. Those with a score of 3 or lower had an incidence of 3.7% of acute appendicitis (96% sensitivity and 67% specificity), and those of a score 7 or higher had an incidence of 77.7% of acute appendicitis (77% sensitivity and 100% specificity). Those with a score between 4 and 6 were therefore defined as equivocal cases and had scores with a sensitivity of 35.5% and specificity of 94%, recommending the performance of a CT scan before surgical consultation.

Two positive cases of appendicitis with Alvarado scores of 2 and 3 would not have undergone CT. They were both males presenting early in the course of the disease. Performing CT only for equivocal cases would have resulted in a delayed diagnosis of appendicitis 3.9% (2/51) but would decrease ED length of stay and time to surgical consultation in others.

Computed tomography scans for patients with scores of 7 and higher should be at the discretion of the surgeon, to rule out other diseases (differential) or to identify complications of the appendicitis [10,26]. Of those with scores 7 and higher, 8 patients had negative scans for appendicitis, but surgical pathology was identified in 7 patients.

Our review was limited by the small sample size and the single center setting. The retrospective nature of our cohort was also a limitation. The low number of patients also made the calculations of specificity less reliable. All findings should be validated in larger, prospective multicenter trials.

5. Conclusion

In the equivocal clinical presentation of appendicitis, as defined by Alvarado scores of 4 to 6, adjunctive CT is recommended to confirm the diagnosis in the ED setting. If clinical presentation suggests acute appendicitis by an Alvarado score of 7 or higher, surgical consultation is recommended. Computed tomography is not indicated in patients with Alvarado scores of 3 or lower to diagnose acute appendicitis. In the setting of the ED, application of a clinical scoring system to the decision to perform CT may reduce unnecessary scans, reducing delay in diagnosis and time in the ED.

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