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Do young patients with high clinical suspicion of appendicitis really need cross-sectional imaging? Proceedings from a highly controversial debate among the experts' panel of 2020 WSES Jerusalem guidelines

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In April 2020, the World Society of Emergency Surgery published the update of the Jerusalem Guidelines on the diagnosis and treatment of acute appendicitis.[1]

As common practice patterns may vary widely across different settings, the statement concerning the need to perform imaging tests to confirm the clinical diagnosis of acute appendicitis for patients younger than 40 years with high Alvarado, Appendicitis Inflammatory Response (AIR) score and Adult Appendicitis Score (AAS) was highly debated (Table 1).

The systematic review of the literature performed during the guidelines development demonstrated that the use of AIR, AAS, and Alvarado scores as clinical predictors of appendicitis can stratify patients into high-risk group with specificity of up to 94%[2–5] (Fig. 1).

During the final Delphi round, the statement (we suggest that cross-sectional imaging [i.e., CT scan] for high-risk patients younger than 40 years [AIR score, 9–12; Alvarado score, 9–10; AAS, ≥ 16] may be avoided before diagnostic +/− therapeutic laparoscopy) was further discussed with participation of many experts in the field of appendicitis representing two different strategies: one using clinical score-based risk stratification, and another which recommend a conditional imaging strategy based on ultrasonography (US) and CT scan if US is negative or inconclusive.

THE SCORE-BASED RISK STRATIFICATION STRATEGY

Diagnostic imaging has limited value in patients younger than 40 years with high probability of appendicitis according to AIR score/Alvarado score/AAS (AIR score, 9–12; Alvarado score, 9–10; and AAS, ≥ 16). In such patients, appendectomy without preoperative imaging may be a cost-effective and time-sparing strategy.

Implementation of a clinical risk score into diagnostics of appendicitis and selective diagnostic imaging has shown to improve outcomes.[3,6]

The prevalence of appendicitis is about 90% in patients with high risk of appendicitis according to the Alvarado score, AAS, or AIR score.[1,7] Conversely, the sensitivity and specificity of CT is reported at 0.91 to 0.94 and 0.90 to 0.95 in three systematic reviews. The corresponding results for US are 0.78 to 0.88 and 0.81 to 0.94, respectively.[8–10] Based on the mean of the sensitivity and specificity cited above, the posterior probability of a positive test would be 0.98 to 0.99 in all the imaging strategies. A positive diagnostic imaging will thus confirm the diagnosis

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TABLE 1. Summary of the Clinical Scoring Systems and Their Interpretation

AIR Score			Alvarado Score			AAS Score			
Vomiting	No	0	Right lower quadrant tenderness	No	0	Pain in right lower quadrant	No		0
	Yes	+1		Yes	+2		Yes		+2
RIF pain	No	0	Elevated temperature (37.3°C or 99.1 °F)	No	0	Pain relocation	No		0
	Yes	+1		Yes	+1		Yes		+2
Rebound tenderness	None	0	Rebound tenderness	No	0	Right lower quadrant tenderness	No		0
	Light	+1							
	Medium	+2		Yes	+1		Yes	Women, aged 16–49 y	+1
	Strong	+3						All other patients	+3
Temp ≥ 101.3°F (38.5°C)	No	0	Migration of pain to the right lower quadrant	No	0	Guarding	No		0
	Yes	+1		Yes	+1		Yes	Mild	+2
								Moderate or severe	+4
Polymorphonuclear leukocytes	<70%	0	Anorexia	No	0	Blood leukocyte count (×10^9)	No		0
	70–84%	+1		Yes	+1		Yes	≥7.2 < 10.9	+1
	≥85%	+2						≥10.9 and <14.0	+2
								≥14.0	+3
WBC count, ×10^9 /L	<10	0	Nausea or vomiting	No	0	Proportion of neutrophils (%)	No		0
	10.0–14.9	+1		Yes	+1		Yes	≥62 and <75	+2
	≥15	+2						2 ≥75 and <83	+3
								≥83	+4
CRP level, mg/L	<10	0	Leukocytosis >10,000	No	0	CRP (mg/L), symptoms < 24 h	No		0
	10–49	+1		Yes	+2		Yes	≥4 and <11	+2
	≥50	+2						≥11 and <25	+3
								3 ≥25 and <83	+5
								≥83	+1
			Leukocyte left shift >75% neutrophils	No	0	CRP (mg/L), symptoms > 24 h	No		0
				Yes	+1		Yes	≥12 and <53	+2
								≥53 and <152	+2
								2 ≥ 152	+1
Interpretation						Interpretation			
AIR score	Risk	Recommendation	Alvarado Score	Risk	Recommendation	AAS score	Risk	Recommendation	
0–4	Low	Outpatient follow-up (if unaltered general condition)	1–4	Low	Discharge	≤10	Low	Discharge without imaging	
5–8	Intermediate	In-hospital active observation with serial reexaminations, imaging, or diagnostic laparoscopy, according to local practice	5–7	Intermediate	Monitoring/ admission	11–15	Intermediate	Imaging	
9–12	High	Surgical exploration	8–10	High	Surgical exploration	≥16	High	Surgical Exploration without preoperative imaging	

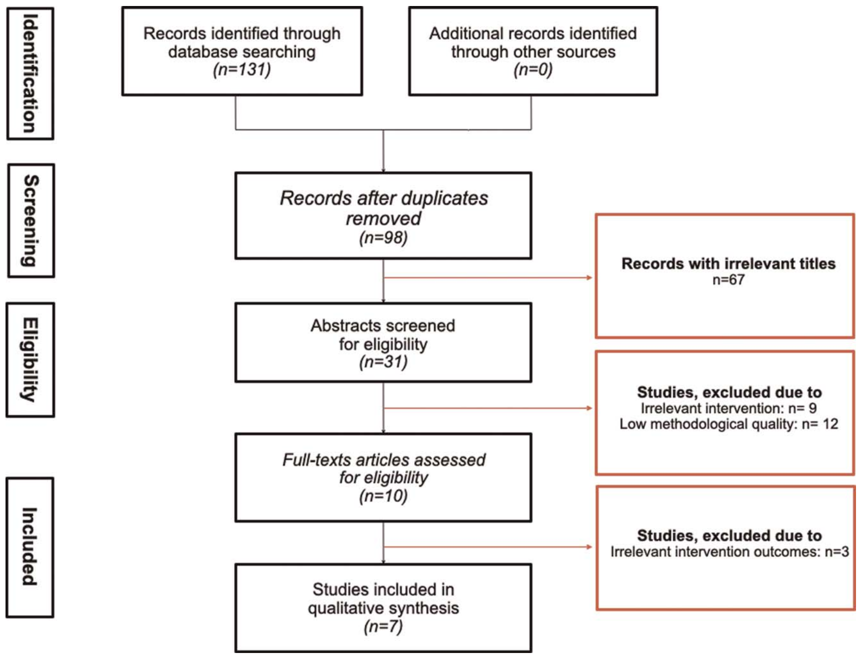

Figure 1. The PRISMA flow diagram for search and selection of articles included in the systematic review.

with very high certainty. However, the posterior probability after a negative imaging test would be from 0.35 in the best scenario to negative 0.64 in the worst. A CT scan or a conditional US/CT strategy in patients with high probability of appendicitis, thus cannot rule out appendicitis with sufficiently high accuracy.

Routine imaging in young patients who have been scored for high probability for acute appendicitis will give an important proportion of patients with false negatives, and the surgeon is still left with an important proportion of patients with continuing symptoms indicating a need for intervention. For the majority of patients in this group, an abdominal exploration, starting with diagnostic laparoscopy is, therefore, strongly indicated (Table 2).

In the study by Scott et al.,[11] an AIR score of 9 or more was very specific (97%) for acute appendicitis, and the majority of patients with appendicitis in the high-risk group (70%) had perforation or gangrene.

The study by Kollar et al. comparing the performance of the AIR score in predicting risk of acute appendicitis to both the Alvarado score and the clinical impression of a senior surgeon showed that the AIR score was more accurate at predicting acute appendicitis than the Alvarado score in patients deemed high risk. The AIR score assigned a smaller proportion of patients to the high probability zone than the Alvarado score (14% vs. 45%) but it did so with a substantially higher specificity (97%) and positive predictive value (88%) than the Alvarado score (76% and 65%, respectively).[12]

Unselected patients with suspicion of acute appendicitis typically have a prevalence of the disease of about 25% to 30%. Using AIR score for risk classification in this group of patients, "advanced" appendicitis can be ruled out with a sensitivity of about 0.98 at a score less than 5, and ruled in with a specificity of 0.98 at a score greater than 8.[13]

So, what imaging can add if the pretest prevalence is greater than 90% is a matter of debate. Indeed, CT has a specificity and sensitivity of about 0.95. If the CT comes out positive, the posttest prevalence will be 99.5%, so it sure will confirm the pretest diagnosis.

If the CT comes out negative, conversely, the posttest probability of acute appendicitis still remains high at about 30%, and negative findings cannot abstain surgeons from exploring the patient in such cases in any case. Obviously, CT can find other diagnoses, so it will help with the differential, but what is the possibility of a differential diagnosis in a young patient with high clinical suspicion of appendicitis? Based on these observations, young, high-score risk male patients should undergo surgical exploration without imaging.

The Imaging-Based Strategy

In patients with high-probability of appendicitis according to AIR score/Alvarado score/AAS and younger than 40 years, CT is the best method to confirm the diagnosis of appendicitis before deciding to operate or—in case of uncomplicated appendicitis—consider to treat without surgery, and to exclude alternative diagnoses.

There is a lot of evidence supporting the high accuracy of imaging for the diagnosis of appendicitis.[14,15] In 2012, these results have been confirmed in a landmark article showing that low-dose CT is associated with a false-positive rate of only 3.2% to 3.5%.[16]

An in-depth analysis of the literature shows that before CT was used for the diagnosis of acute appendicitis, 20% of patients taken to surgery based on a clinical and laboratory diagnosis had a normal appendix. Only after CT availability, negative appendectomy rate is lowered overall (20% to 7%), in men (11% to 5%), in women (35% to 11%), in boys (10% to 5%), and in girls (18% to 12%).[15]

In the study by Sammalkorpi et al.,[4] the AAS was implemented in the diagnostic workup of adult patients suspected of

TABLE 2. Main Results of the Included Studies (Search Details: Appendicitis and Clinical Scores—Titles and Abstracts. Publication Date: 5 Years)

Authors	Year of Publication	No. Enrolled Patients	Study Design	Main Findings Related to Patients High-Probability	Conclusion
Coleman et al.	2018	492 (110 AS ≥ 7)	Retrospective review of patients (for whom Alvarado score was calculated) undergoing CT to rule out acute appendicitis	100% of female patients with Alvarado score = 10 and male with Alvarado score ≥9 had acute appendicitis confirmed by surgical pathology	Males with an Alvarado score of ≥9 and females with Alvarado score of 10 should be considered for treatment of acute appendicitis without imaging
Andersson et al.	2017	1,152 (333 AIR > 8)	Pre-post interventional study with a nested randomized trial. The AIR score-based algorithm was implemented during the intervention period	A smaller proportion of patients in the high-risk score group had diagnostic imaging in the intervention phase compared with the baseline phase (38.5% vs. 53%, $p = 0.021$), without any difference in terms of negative appendectomy rate, appendectomies, admission to hospital, readmission within 30 d, missed appendicitis	AIR score-based risk classification can safely reduce the use of diagnostic imaging also in high-risk score patients
Sammalkorpi et al.	2017	822 (386 AAS ≥ 16)	AAS used to stratify patients into groups of high, intermediate, and low probability of appendicitis. Diagnostic performance of CT scan and US was compared between these patient groups	For patients in the high-probability group who underwent CT, pretest probability of acute appendicitis was 78.9%. The posttest probability for appendicitis was for a positive test 98.9% and for a negative test 0%. The accuracy of CT was in this group 99.1%. Pretest probability of appendicitis in patients who underwent US was 75%. The posttest probability for appendicitis was for a positive US of 95% and for a negative 68.8%. The accuracy of US was in this group 55.8%	In the high-probability group, for patients who did not have diagnostic imaging, the probability of appendicitis was 93%. CT should be performed when there is clinical suspicion of other diagnosis than appendicitis
Sammalkorpi et al.	2017	908 (246 AAS ≥ 16)	The AAS was implemented in diagnostics of adult patients suspected of acute appendicitis. The study population (908 patients) was compared with a reference population of 829 patients suspected of acute appendicitis originally enrolled for the study of construction of the AAS	The AAS stratified 49% of all appendicitis patients into high-risk group with specificity of 93.3%. Negative appendectomy rate was 5.3%	AAS is a reliable tool for stratification of patients into selective imaging. Mandatory imaging could be restricted for patients with equivocal appendicitis according to clinical scoring
Kollár et al.	2015	182 (N/A)	All parameters included in the AIR and Alvarado scores as well as the initial clinical impression of a senior surgeon were prospectively recorded. Predictions were correlated with the final diagnosis of appendicitis	The three methods of assessment stratified similar proportions (40%) of patients to a low probability of appendicitis, with a false negative rate of 8% that did not differ between the AIR score, Alvarado score or clinical assessment. The AIR score assigned a smaller proportion of patients to the high probability zone than the Alvarado score (14% vs. 45%) but it did so with a substantially higher specificity (97%) and positive predictive value (88%) than the Alvarado score (76% and 65%, respectively)	The AIR score is more accurate at predicting appendicitis than the Alvarado score in patients deemed high risk.

Scott et al.	2015	464 (39 AIR ≥ 9)	Prospective observational study. The AIR score was calculated for all patients admitted with suspected appendicitis. The diagnostic performance of the AIR score and the potential for risk stratification to reduce admissions, optimize imaging and prevent unnecessary explorations were assessed	An AIR score of ≥9 was very specific (97%) for appendicitis, and the majority of patients with appendicitis in the high-risk group (70%) had perforation or gangrene. The cut-off score of 5, for differentiating low-risk from intermediate- and high-risk groups, yielded a sensitivity for all cases of appendicitis of 90%, specificity 63% and a negative predictive value of 94%. The corresponding values for advanced appendicitis alone were 98% for sensitivity, 54% for specificity and a negative predictive value approaching 100%	The AIR score maintains a high sensitivity for all cases of appendicitis and particularly for advanced disease (98%). The high-risk cutoff demonstrated excellent specificity for appendicitis (97%), of whom the majority (70%) had advanced disease
Tan et al.	2015	350 (187 AS ≥ 7)	Prospective data collection on consecutive patients with suspected appendicitis who were evaluated with CT scans. The AS for each patient was calculated at admission and correlated with eventual histology and CT findings	Alvarado scores of ≥7 in males (AS 7, $p = 0.513$; AS 8, $p = 0.442$; AS 9, $p = 0.398$; AS 10, $p = 0.896$) and 9 and above in females (AS 9, $p = 0.513$; AS 10, $p = 0.638$) have positive likelihood ratios comparable to those of CT scan	An AS ≥7 in males and ≥9 in females had positive likelihood ratios not significantly different from those of CT scan. These patients are least likely to benefit from CT evaluation

AS, Alvarado score; N/A, not applicable.

acute appendicitis, of whom 48% indeed had appendicitis. Overall, 1,545 patients with suspected appendicitis underwent an appendectomy, of which as much as 13.6% were not inflamed. The AAS high-probability group (AAS ≥16) comprised 439 patients, of whom 386 (87.9%) indeed had an appendicitis at surgery. Using only the AAS and no imaging, the posttest probability for appendicitis increased to 92.6%, equivalent to a negative appendectomy rate of 7.3%. Use of CT in this high probability group outperformed the use of the AAS without imaging. In the high probability group, CT had been performed in only 26% of patients, and CT pretest probability of acute appendicitis increases from 78.9% to 98.9% posttest probability for a positive CT and 0% for a negative CT, equivalent to a negative appendectomy rate of 1.1%. This reflects an almost perfect accuracy of 99.1%. The noted difference in negative appendectomy rates in high-risk groups seems clinically relevant (7.3% for AAS vs. 1.1% for CT).

Some experts debated about the great difference between male and female patients presenting with right iliac fossa pain. In the Right Iliaca Fossa pain Treatment study, negative abdominal exploration on suspicion of appendicitis is high in both men (15%) and women (10%), suggesting a too low threshold and too wide indications for abdominal exploration.[13]

The probability of a female patient presenting with right iliac fossa pain to have appendicitis is only 25%. Starting the diagnostic workup with an US followed by CT scan, in case of negative or inconclusive US, should be considered the most cost-effective pathway.

This could be different in male patients. In fact, for male patients with right iliac fossa pain with classical presentation (combination of migration of pain to the right lower quadrant, tenderness in the right lower quadrant, and rigidity), the probability of having acute appendicitis can be around 90%. However, also in male patients, the proportion of all patients with appendicitis that present with classical symptoms is unfortunately low.[6]

In the past, diagnostic laparoscopy was considered a standard procedure to reduce the rate of negative appendectomies and, above all, a useful method for obtaining other (mostly gynecologic) diagnoses.[17] However, diagnostic laparoscopy has a 5% complication rate and should not be used as diagnostic tool rather than therapeutic intervention.[18,19]

In low-income countries with limited or no excess to CT, for young male patients (<40 years) with high AIR or AAS scores (AIR score, 9–12, AAS ≥ 16), the high probability of appendicitis may be sufficient for exploratory laparoscopy and eventually appendectomy as the best available option while settling for a higher negative appendectomy rate than with the use of CT.

In middle- and high-income countries, contrariwise, the viewpoint that critically ill patients should be taken to surgery without imaging is no longer considered a valid option by some authors, because it may lead to numerous problems because of undirected surgery and unwanted delays of the correct treatment (which may be nonsurgical) when alternative diagnoses are found during surgery.

So, in this day and age, accurate imaging is needed also in high-score patients when there is disagreement between scoring and the clinical evaluation, preferable in a conditional CT strategy (ie, US first and CT only in negative or inconclusive US) before surgery. Moreover, when antibiotic treatment for uncomplicated appendicitis becomes more standard, differentiation between complicated and uncomplicated appendicitis becomes crucial because of differences in treatment. Imaging or scoring systems, including imaging features, are needed for that purpose.

What Imaging Technique Should Be Used? Ultrasonography or CT Scan or a Step-Up Approach of the Two?

If an imaging investigation is indicated based on clinical scoring, point-of-care ultrasound is the most appropriate first-line diagnostic tool in adults with suspected appendicitis. Conditional CT (CT after negative/inconclusive ultrasound findings) is an effective diagnostic strategy for suspected appendicitis.

The most cost-effective diagnostic strategy is dependent on risk stratification carried out by clinical scores. At a prevalence less than 16% and greater than 95%, patients may forego imaging completely. For patients with a risk of acute appendicitis between 16% and 67%, it is cost-effective to perform an initial US and forego additional imaging if the US does not visualize the appendix but shows no secondary signs of inflammation. Conversely, when the pretest probability of appendicitis is greater than 67% but less than 95%, it is cost-effective to follow-up all nonvisualized US with a CT even without secondary signs of inflammation on US.[20]

Several evaluations of diagnostic strategies for young patients with suspected appendicitis favor a conditional CT scan strategy as the most judicious diagnostic pathway, with CT scan performed only after a negative or equivocal US.

In a recent meta-analysis of 17 studies (2,385 patients), US exhibits a pooled sensitivity of 84% and a pooled specificity of 91% in the general population, with even better diagnostic performance in children (sensitivity, 95%; specificity, 95%). Higher sensitivity and specificity tend to be associated with an appendix diameter cutoff value of 7 mm.[21]

Results from the OPTIMA diagnostic trial demonstrated that, although CT remained the most sensitive imaging investigation for detecting urgent conditions in patients with abdominal pain, a conditional CT strategy, using US first and CT only in those with negative or inconclusive US before surgery resulted in the best sensitivity and may lower exposure to radiation. In this study, sensitivity was 89% for CT and 70% for US. A conditional strategy with CT only after negative or inconclusive US yielded the highest sensitivity, missing only 6% of urgent cases. Conversely, just a clinical diagnosis resulted in many false-positive urgent diagnoses.[6] The optimizing imaging in suspected appendicitis trial, instead, showed an 8% false-positive rate of conditional CT.[22]

Although CT scans have shown to be a solid diagnostic tool and have led to a significant decrease in negative appendectomy rates, the increasing use of radiation for diagnostic purposes has raised concerns about possible cancer risks, particularly after exposures in childhood. Extrapolation models estimated that 1.5% to 2.0% of cancers in the United States might be actually attributable to CT scans.[23] For a single abdominal CT study in a 5-year-old child, the estimated lifetime risk of radiation-induced cancer is 26.1 per 100.000 in female patients and 20.4 per 100.000 in male patients.[24]

Strategies to reduce radiation exposure in young patients with right iliac fossa pain can be implemented by use of low-dose CT protocols, which are equally accurate as compared with standard-dose protocols. The OPTICAP randomized controlled trial reported that the diagnostic accuracy of contrast enhanced low-dose CT was not inferior to standard CT in diagnosing acute appendicitis or distinguishing between uncomplicated and complicated forms in patients with a high likelihood of acute appendicitis.[25]

CONCLUSIONS

The use of AIR, Alvarado, and AAS scores can stratify patients suspected of acute appendicitis into low-, intermediate- and high-probability groups. Patients with low probability of appendicitis may be discharged from the emergency department without imaging, whereas patients with intermediate probability benefit from diagnostic imaging. In patients younger than 40 years, a high-probability score for acute appendicitis (AIR score, 9–12; AAS, ≥ 16) may be used to select patients in which imaging is not needed because CT has limited additional diagnostic value in that particular setting. However, when differentiation between uncomplicated and complicated appendicitis becomes more important when uncomplicated disease can be treated without surgery, imaging is most likely still needed.

AUTHORSHIP

All authors contributed equally in the study conception and design, literature search, acquisition and interpretation of data, drafting and critically revising the article for important intellectual content, and final approval of the version to be published.

DISCLOSURE

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