

Background:

Acute appendicitis is the most common abdominal emergency in children. Imaging may play a key role in the accurate and prompt diagnosis of suspected appendicitis. Computerized tomography (CT) has high sensitivity for diagnosis of appendicitis. However, due to radiation exposure, providers in the emergency department (ED) are preferring ultrasound (US) as imaging modality. Point of care ultrasound for appendicitis performed in ED has high effectiveness in clinical decision making of ED physicians. Although the specificity of US is high, the sensitivity is variable depending on the operator. It is unclear which children should have advanced imaging after US is considered non-diagnostic when performed by the ED physician. The purpose of this study was to determine a method for identification of children who will benefit from a CT scan after a non-diagnostic US.

Patients & Methods :

We retrospectively reviewed patients 0-18 year old, who presented to the ED with complaints of abdominal pain, during 2011-2015 and while in the hospital underwent abdominal US as the first imaging study performed by an ED physician, and that subsequently had a CT scan. We used univariate and multivariate methods for comparing patients who did and didn’t have appendicitis on CT after non-diagnostic US. Multivariate analysis was performed using logistic regression to determine what variables were independently associated with appendicitis.

Data collection:

Data included the following: demographic information, medical history, physical examination, laboratory studies, imaging and final diagnosis. Peritoneal signs were interpreted as positive if the child had at least one of the following findings; rebound tenderness, guarding, heel drop sign, tapping pain and psoas sign. Leukocytosis was defined as more than 10,000 White Blood Cell counts (WBC) in mm³. All US exams were performed by an ED physician. US exams were classified as positive for appendicitis if the ED physician documented ‘Visualization of non-compressible swollen appendix (appendix diameter>6mm)’, ‘Appendicolitis’, or ‘Peri-appendiceal fluid’. CT studies were classified as positive for appendicitis if the radiology report stated ‘Enlarged or thickened appendix’, ‘Consistent with acute appendicitis’ or ‘Consider appendicitis’.

Predicting Need for Additional CT scan in Children with a non-diagnostic Ultrasound for Appendicitis in the Emergency Department.

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Results & Discussion :

A total of 473 patients with complaints of abdominal pain had both US and CT during the study period. We excluded 145 patients who had (1) imaging studies due to trauma (34, 7.2%), (2) history of appendicitis (11, 2.3%), (3) US or CT documented before presenting to our ED (63, 13.3%), (4) CT performed before US (10,2.1%), (5) US findings not found in the EMR (11, 2.3%) and (6) suspected other diagnoses than appendicitis based on physical examination, clinical history and US (16,3.4%). Thus, a total of 328 (69.3%) records were analyzed (Figure 1).

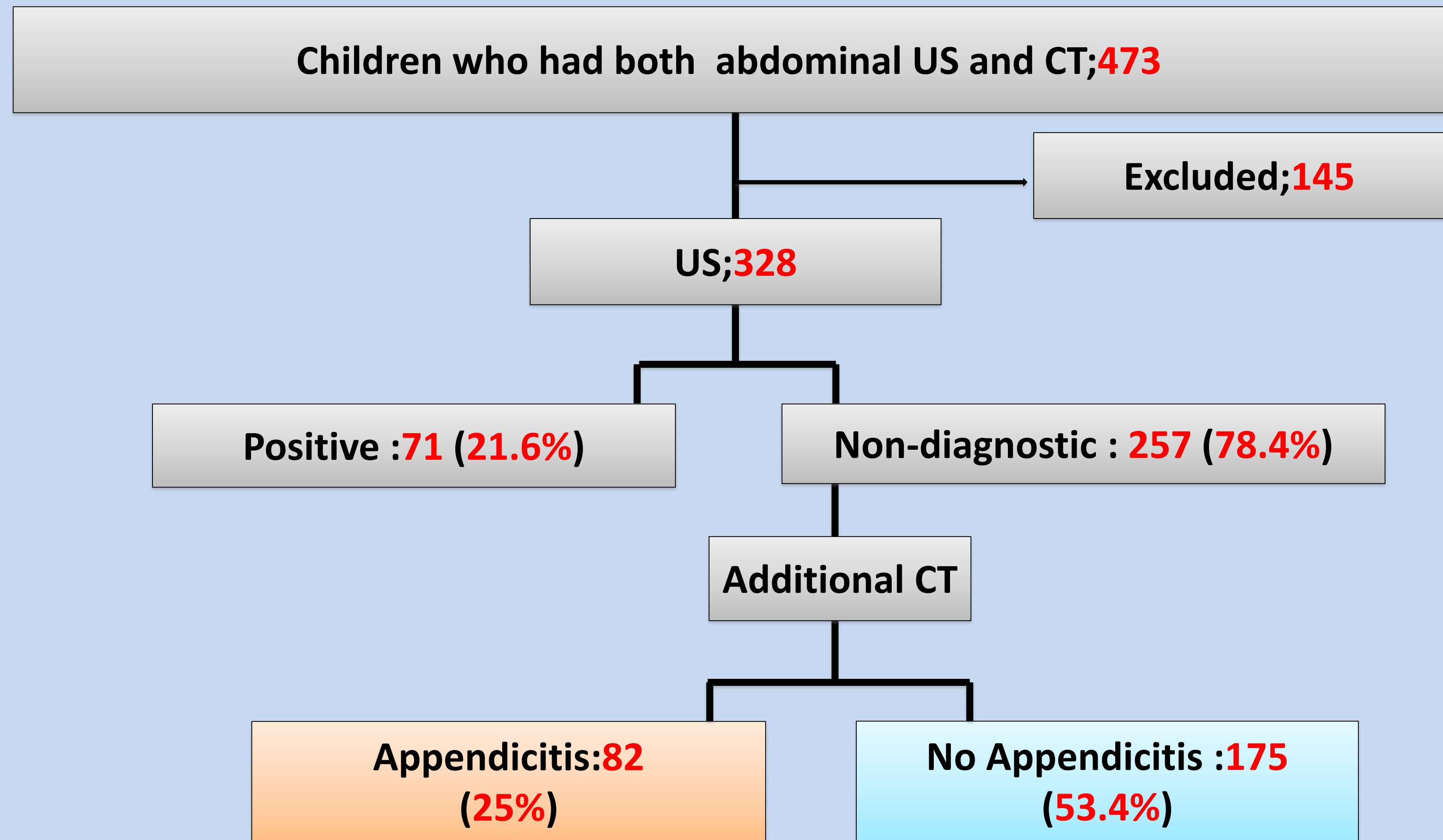


Figure 1: Flow of study

Among 257 patients with a non-diagnostic US, patients who reported vomiting or had right low abdominal quadrant (RLQ) tenderness, peritoneal signs or leukocytosis were more likely to have appendicitis on CT (p<0.05). There were no statistical differences for gender, BMI, presence of fever, diarrhea, or duration of abdominal pain. We then conducted a multivariate analysis and included age, vomiting, RLQ tenderness, peritoneal signs and leukocytosis in the model. Only RLQ tenderness (Odds Ratio: 2.84, 95%CI: 1.07-7.53), peritoneal signs (Odds Ratio: 11.37, 95%CI: 5.08-25.47) and leukocytosis (Odds Ratio: 21.88, 95%CI: 7.95-60.21) were considered significant predictors of appendicitis. Nagelkerke R square was .594. Percent of correct classification was 64.6% for appendicitis and 92.3% for no appendicitis.

With combinations of the three predictors retained in the multivariate model (RLQ tenderness, peritoneal sign, leukocytosis), we developed profiles for patients in whom US was non-diagnostic (Table 1). One hundred seventeen (96%) of patients who met 0 or 1 of these features had no appendicitis on CT, while 5 patients (4%) had appendicitis. Based on the prevalence of appendicitis cases in each of the subgroups corresponding to these profiles, the following decision rule was devised to select patients who may benefit from a CT (Figure 2). If patients with non-diagnostic US meet at least 2 predictors, a CT should be considered. This decision rule has a sensitivity of 94%, specificity of 67%, PPV of 57% and NPV of 96%. If we had applied this decision rule to our study group, we could have avoided about 65% of CT scans that were negative for appendicitis with a much lower false negative rate of 4%.

WBC ≥10,000	Peritoneal signs	RLQ tenderness	Appendicitis on CT	No appendicitis on CT	Total
0 or 1 characteristics, n (%)			5(4)	117(96)	122
1 or 2 characteristics, n (%)			77(57)	58(43)	135
Total, n (%)			82(32)	175(68)	257

Table 1 : Profiles of Patient Characteristics associated with appendicitis among patients with non-diagnostic US.

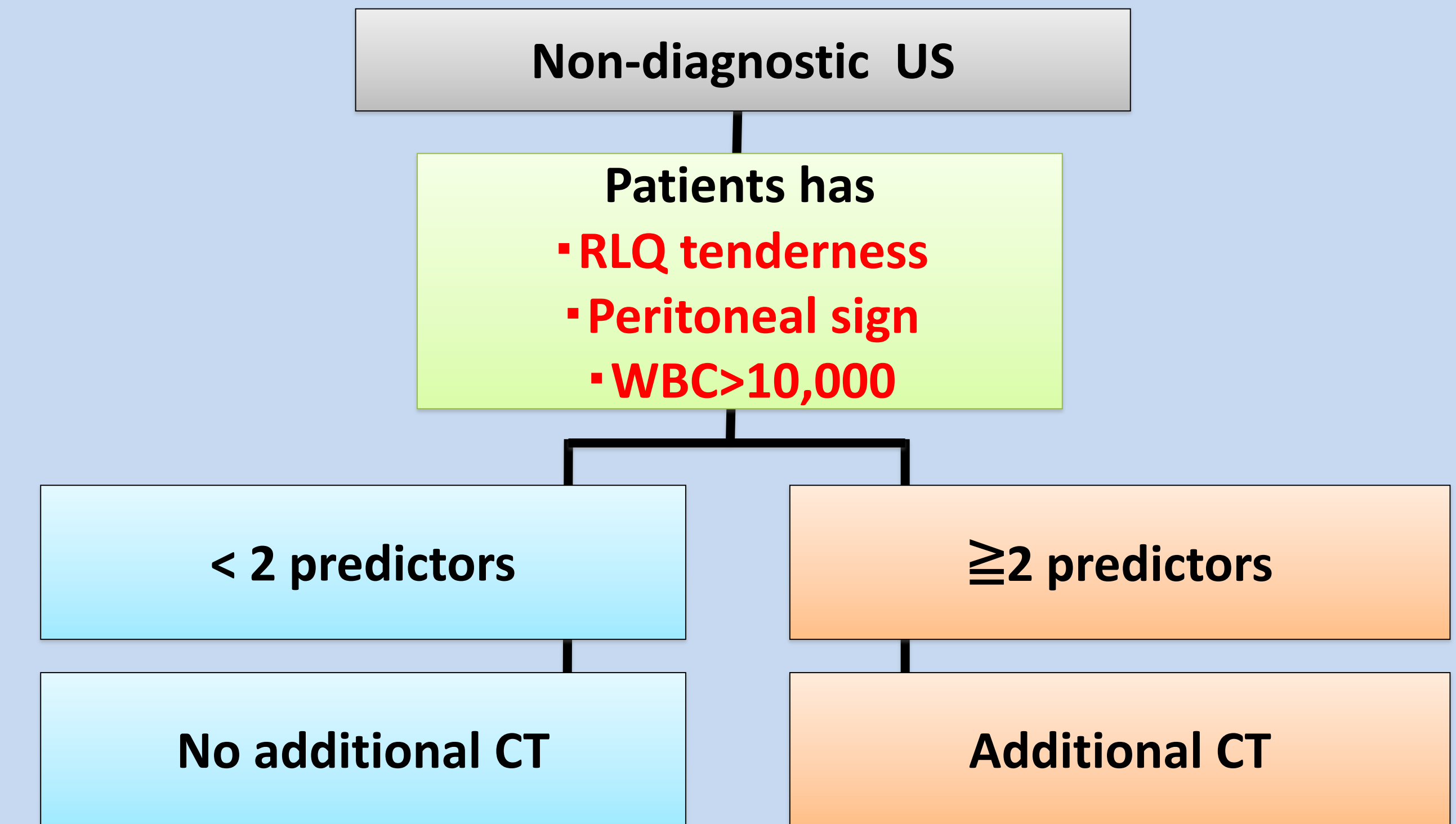


Figure 2 : The clinical decision rule

Conclusion & Perspectives :

Ordering CT should be considered after non-diagnostic US for appendicitis only when children meet at least 2 predictors of RLQ tenderness, peritoneal signs and WBC>10,000 in mm³. This decision rule provides high sensitivity and NPV, and unnecessary CT may be avoided.