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Validation of the pediatric Appendicitis Risk Calculator (pARC) in a Community Emergency Department Setting

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Abstract

Objective—The pediatric Appendicitis Risk Calculator (pARC) is a validated clinical tool for assessing a child's probability of appendicitis. We aimed to assess the performance of the pARC in community emergency departments (EDs), and to compare the performance of pARC with the Pediatric Appendicitis Score (PAS).

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Author Contribution

DC, DV, and DB conceived the study and its design. AK, EK, DV, DB, DM, AR, and MR obtained research funding. DC, DB, AK, EK, and LS performed manual chart review. MW and GVB performed the programming and analysis. DB oversaw the study as a whole. DC drafted the manuscript and all authors contributed substantively to its critical revision and its final approval. DC takes responsibility for the paper as a whole.

Meetings

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Conflict of interest

All authors have nothing to disclose.

Methods—We conducted a prospective validation study from 10/1/16 to 4/30/18 in 11 community EDs serving general populations. Patients 5–20.9 years old with a chief complaint of abdominal pain and ≤5 days of right-sided or diffuse abdominal pain were eligible for study enrollment. Our primary outcome was the presence or absence of appendicitis within 7 days of the index visit. We reported performance characteristics and secondary outcomes by pARC risk strata and compared the receiver operator characteristic (ROC) curves of the PAS and pARC.

Results—We enrolled 2,089 patients with a mean age of 12.4 years, 46% of whom were male. Appendicitis was confirmed in 353 patients (16.9%), of whom 55 (15.6%) were perforated. Fifty-four percent of patients were very low (<5%) or low (5 – 14%) predicted risk, 43% were intermediate-risk (15 – 84%), and 4% were high-risk (≥85%). In the very low- and low-risk groups, 1.4% and 3.0% of patients had appendicitis, respectively. The area under the ROC curve was 0.89 (95% CI 0.87–0.92) for the pARC compared to 0.80 (95% CI 0.77–0.82) for the PAS.

Conclusion—The pARC accurately assessed appendicitis risk for children 5 years and older in community EDs and the pARC outperformed the PAS.

Introduction

Pathological inflammation of the appendix—appendicitis—is the most common surgical emergency in children.[1] While treatment of appendicitis is effective, making the diagnosis in children can be challenging.[2–5] This diagnostic dilemma fuels practice variability and potentially increases unnecessary imaging.[6–10] Of specific concern, increased use of computed tomography (CT) scans exposes children to ionizing radiation and the potential risk of future malignancies without adequate evidence of improved appendicitis outcomes.[11–15] High utilization of CT is of particular concern in the community setting, where in a 2008–2012 review of over 2,500 pediatric patients, more than half of patients who underwent appendectomy had a CT scan; and those in general EDs were about 8 times more likely to undergo CT imaging than a child evaluated in a facility with specialized pediatric resources.[16] Ultrasound use shows promise and may mitigate overuse of CT, but its performance is operator- and facility-dependent.[17] Reliably identifying a patient's risk of appendicitis could improve care and reduce unnecessary imaging as well as associated costs and complications. To this end, appendicitis risk scores have been developed and studied.

The pediatric appendicitis risk calculator (pARC) is one such tool.[18] Variables include sex, age, duration of pain, guarding, pain migration, maximal tenderness in the right-lower quadrant, and absolute neutrophil count (ANC). The pARC incorporates subtle and previously observed interactions by age and gender regarding appendicitis risk and utilizes ANC on a continuous scale. Thus, the pARC requires use of an online or electronic health record (EHR) integrated calculator, differing from integer-tally scores such as the Alvarado or the Pediatric Appendicitis Score (PAS).[19,20] In its prior validation in an academic children's hospital cohort with a 35% baseline risk for appendicitis, the pARC was able to accurately sort nearly half of patients into either a low (<15%) or high (≥85%) probability of appendicitis category.[18] This ability to discriminate high- and low-risk strata is an improvement over other scores, since accurate classification at either end of the risk spectrum may obviate the need for imaging. Yet, like many pediatric clinical decision tools, those for pediatric appendicitis have rarely been studied in the community setting in which

they are most likely to be used.[21,22] Validation in the setting in which a tool is employed is a core tenet of a robust decision tool.[22] The aims of the current study were to evaluate the performance of pARC when used in a community emergency department (ED) setting and to compare its performance to the PAS.

Methods

Study Design and Setting

We conducted this multicenter, prospective, observational cohort validation study of the pARC from 10/1/2016 to 4/20/2018 in 11 community EDs serving general populations in Kaiser Permanente Northern California (KPNC). These study centers are a subset of a larger 17-center cluster-randomized trial of electronic clinical decision support to aid in the diagnostic evaluation of children with acute abdominal pain (NCT02633735). KPNC is an integrated healthcare delivery system that provides comprehensive medical care for more than 4 million members, who are representative of the ethnic and socioeconomic diversity of the surrounding population.[23] KPNC is a learning healthcare system with an applied research agenda, and is supported by a comprehensive integrated EHR (Epic, Verona, WI), which includes inpatient, outpatient, emergency, pharmacy, laboratory and imaging data.[24,25] The KPNC Institutional Review Board approved the study with a waiver of informed consent.

The 2017 cumulative annual census of the 11 participating EDs was 793,000 with over 136,000 (17.2%) patients in our study age range of 5 to 20.9 years. None of these facilities are university-based, but 5 have academic emergency medicine affiliations and 4 are referral centers for pediatric appendectomies. Referral centers staffed pediatric surgeons, and non-referral centers varied in the age at which they would transfer patients to KPNC referral centers for appendectomy. All EDs were staffed by general emergency medicine residency-trained (board-certified or board-eligible) physicians. EDs had 24-hour access to CT imaging and variable but daily access to ultrasonography.

Selection of Participants

We included ED patients aged 5–20.9 years with a chief complaint of recent-onset (≤120 hours) generalized or right-sided abdominal pain. Physicians were trained by a local study-champion to enroll eligible patients into a web-services based clinical decision support system (CDSS) from within the ED Navigator menu of the EHR. This KPNC CDSS has been successfully used in other clinical applications.[26,27] In addition to CDSS familiarity from prior studies and ongoing education by a study-champion, we began sending electronic text alerts to physician smartphones three months into the study period to notify them that a patient assigned to them in the EHR might be study-eligible.[28]

As in the derivation and validation studies, patients were ineligible for enrollment if they had any of the following: abdominal trauma within 7 days, current pregnancy, history of prior abdominal surgery including appendectomy, inflammatory bowel disease, chronic pancreatitis, sickle cell anemia, cystic fibrosis, and other conditions that might affect the ability to obtain an accurate history or physical exam (comprehensive exclusion list available

upon request). In cases of multiple enrollments due to more than one visit, only the first enrollment was included. The CDSS was open to advanced practitioners and trainees, but we limited data inclusion to that entered by attending physicians.

Data Collection

After opening the CDSS, physicians were presented with pre-populated patient-specific eligibility criteria for editing and confirmation (screenshots of the CDSS are in Figure E1, available online at http://www.annemergmed.com). If the patient met study criteria, the physician advanced the CDSS to the data collection screen to input seven variables from the history and physical examination. For this analysis, pARC scores were calculated post-hoc in patients for whom a white blood cell count (WBC) was obtained in the ED and where pARC CDSS clinical data were otherwise complete. At this point as part of the parent study, physicians at certain intervention sites were presented the pARC score, and others at control sites were not.

Outcome Measures

Our primary outcome measure was the presence or absence of acute appendicitis within 7 days of the index visit. Acute appendicitis was identified by screening for 7 days from the index visit for an ED or hospital diagnosis of appendicitis and/or Current Procedural Terminology (CPT®) code for appendectomy. Our outcomes verification process reflected principles established for robustness in research involving chart review.[29] Outcome reviewers were blinded to the pARC score and the PAS. If operative and pathology reports were available, outcome verification was performed by text string search algorithms and manual chart review. If these two methods were discordant or ambiguous then a second reviewer assessed the data. Discordant manual assessments were adjudicated by a third reviewer. If manual review confirmed that no operative or pathology reports were available, then the chart, imaging, and discharge medication list were reviewed to identify the impression of acute appendicitis with a non-operative treatment plan. An imaging or ED diagnosis alone of appendicitis was insufficient to determine the outcome as appendicitis.

Our secondary outcomes were appendiceal perforation, negative appendectomy, and missed appendicitis within 7 days of the index visit. Appendiceal perforation for those undergoing appendectomy was determined by the surgeon’s intra-operative note for keywords such as: presence of abscess, peritonitis, complex appendicitis, or purulent material. Enrolled patients who were discharged after their index ED visit and subsequently met our study definition of acute appendicitis within 7 days were considered to be a missed appendicitis case. We searched our claims database for potential missed appendicitis-related healthcare visits outside of KPNC whose index visit may have been within KPNC. Cases of missed appendicitis were adjudicated by four study investigators (AK, EK, DB, LS). Negative appendectomies were defined as appendectomies in which the pathology revealed no evidence of appendiceal inflammation.

We tracked appendectomy procedures and principal diagnosis of appendicitis for patients who were eligible to be enrolled but were not enrolled. We report the size of this cohort and the presumed appendicitis rate.

pARC and PAS

For each patient, we calculated the pARC score and the PAS (see Table E2 for pARC and PAS variables, available online at http://www.annemergmed.com). The pARC variables include sex, age, duration of pain, guarding, pain migration, maximal tenderness in the right-lower quadrant, and ANC.[18] When ANC was unavailable (5% of cases), it was estimated from the WBC (see Table E5, available online at http://www.annemergmed.com).[18,28] The PAS variables include cough / percussion / hopping tenderness in the right lower quadrant (RLQ), anorexia, pyrexia, nausea / emesis, tenderness over the right iliac fossa, leukocytosis, neutrophilia, and migration of pain to the RLQ.[30] The pARC differs from the PAS in that it provides the risk of appendicitis on a continuous scale. The pARC was developed in a sample of children with suspected appendicitis defined as undergoing laboratory testing, diagnostic imaging, or a surgical consultation for appendicitis in patients 5 to 18 years old, with a 40% rate of appendicitis.[18] The pARC equation can be found in Table E5 (available online at http://www.annemergmed.com).

We sorted pARC into one of seven clinically-actionable risk strata: <5%, 5–14%, 15–24%, 25–49%, 50–74%, 75–84%, and ≥85%. Qualitatively, we described the <5% group as very low-risk, 5–14% as low-risk, 15–84% as intermediate-risk, and ≥85% as high-risk. These strata were chosen by multidisciplinary study-team consensus as having distinct diagnostic or management approaches.

Validation

We report discriminatory performance features (sensitivity, specificity, positive predictive value, negative predictive value, and positive and negative likelihood ratios) and secondary outcomes (missed appendicitis, perforation, and negative appendectomy) by risk strata. Overall discriminatory performance was evaluated and compared for the pARC and the PAS by generating the receiver operating characteristic (ROC) curve and the area under the curve (AUC) statistic. We also report the AUC statistic range by facility. In order to best represent the discriminatory performance of the pARC, we initially excluded patients transferred outside of KPNC. In sensitivity analysis, we included these transfer patients with a presumed diagnosis of appendicitis. As part of validating the pARC in this newly-studied population, we estimated the calibration intercept and slope. This was achieved by regressing the logit of pARC values to the observed appendicitis outcome using logistic regression,[31] plotting the observed and predicted appendicitis risk from pARC and calibrating pARC according to a decile partition of the distribution of pARC (calibration plot), and computing the Hosmer and Lemeshow Goodness of Fit (H-L GOF) test statistic. In addition, we estimated the H-L GOF test for the PAS.[32,33] The data analysis was generated using SAS/STAT software, Version 9.4, SAS Institute Inc, Cary, NC, USA.

Very Low pARC Score with Appendicitis

We manually reviewed all cases with a very low pARC score (<5%) who were diagnosed with appendicitis. We present the collected variables for each of these cases as well as the pARC score and the presence of perforation or missed appendicitis.

Results

Study Population

Over the 18-month study period, our study included 2,089 patients from 11 community facilities with a median of 151 patients (interquartile range [IQR] 107–283) per facility. Four hundred and fifteen providers enrolled patients with a median of 4 enrollees per provider (IQR 2–7). The median patient age was 12 years (IQR 9–16). Clinical characteristics and study flow are provided in Table 1 and Figure 1, respectively. Of enrolled patients, 46% were male and 56% presented with <24 hours of pain. The most commonly reported symptoms were nausea or vomiting (69%). The median white blood cell count was 9.9 (IQR 7.5–13.5). Appendicitis was confirmed in 353 cases (16.9%).

Score Validation

Performance characteristics for the pARC are shown in Table 2 and Table E3 (available online at http://www.annemergmed.com). Fifty-four percent of patients had a low- or very low-risk score and 4% had a high-risk score. The observed rate of appendicitis was 1.4% and 3.0% within the very low- and low-risk strata respectively, and 84.8% in the high-risk strata. The two lowest pARC strata had very high sensitivity, 100.0% and 97.5% for pARC <5% and 5–14%, respectively. The two highest pARC strata had very high specificity, 97.8% and 99.3% for pARC 65–84% and ≥85%, respectively.

The overall pARC discriminatory performance was high, with an AUC of 0.89 (95% CI 0.87–0.92), which was better than the PAS AUC of 0.80 (95% CI 0.77–0.82). When compared to the PAS at any specificity, pARC sensitivity was higher (Figure 2). We also calculated discriminatory performance for both scores treating all patients transferred out of system (20 patients) as presumed appendicitis cases, instead of excluding them. No change in discriminatory performance was noted. Across facilities, the pARC AUC ranged from 0.85 to 0.94. The pARC demonstrated adequate calibration as seen in Figure 3. Calibration intercept was −.615, slope was 1.10, and H-L GOF test 11.81 (8 df, p=.16). The PAS H-L GOF test was 2.4 (5 df, p= .78).

Secondary Outcomes

The negative appendectomy rate (NAR) was 6.5%. The NAR was highest in the very low and low pARC scores (30.8% and 22.2% respectively) and 0.9% in our two highest risk strata combined (Table 2). The overall perforation rate was 15.6% and there were no perforations in the two lowest risk strata. There were 9 cases of missed appendicitis, 2 of which were in the very low-risk pARC strata.

Patients Not-Enrolled

During our study period there were 14,589 patients 5–20.9 years of age with a chief complaint of abdominal pain who received care in our 11 participating EDs but were not enrolled in our study. Of these, 126 (0.86%) had appendicitis. Demographic data comparing the enrolled and not-enrolled cohorts is available in Table E4 (available online at http://www.annemergmed.com).

Very Low pARC Score

Nine patients (1.4%) with pARC scores <5% had appendicitis (Table 3). Six of these patients were female, and 6 patients reported <24 hours of abdominal pain at the time of presentation. Several patients had post-enrollment documentation that suggested a progressing examination, but only one had clear documentation that would have moved the patient to an intermediate-risk pARC score, if recalculated. All nine patients had a normal WBC (3.7–11.1 $\times 10^3/\mu L$) and ANC (1.8–7.9 $\times 10^3/\mu L$) for our system reference. Two of these cases were missed appendicitis; both patients had <24 hours of symptoms. There were no cases of appendiceal perforation among those with a very low pARC score.

Limitations

There are several limitations specific to our study. Although we have established that the pARC is accurate and safe for sorting patients into risk strata for appendicitis, we have not yet shown that it can be used to improve clinical care, such as lowering the rate of CT scans. Work to demonstrate improved imaging utilization is ongoing by our study team. Additionally, in contrast to previously studied integer-tally risk scores such as the PAS, the pARC requires the use of a calculator. Although these calculations could be achieved via integration with the EHR or web-based tools, it may prove a barrier in some clinical environments.[34] If implementation hurdles can be overcome, there is evidence of substantial benefit supporting the efficacy of CDSS.[27,35–38]

Although the size of our cohort and the setting from which it was derived represent a substantial sample, our results may not be applicable to unique practice environments. As in the original pARC validation study, we did not include patients younger than 5 years of age, due to the inconsistent and protean manifestations of appendicitis in the very young.[18,39,40] Despite these limitations, our pARC validation would apply to the majority of pediatric patients in the United States presenting to the ED with possible appendicitis.[23]

Discussion

In this study of the pARC performance within an integrated community-based health care system, pARC was validated as a reliable tool for classifying patients with suspected appendicitis into clinically relevant risk strata. The risk score did so while outperforming the PAS in terms of discrimination and overall model performance. This validation study may provide clinicians working in community EDs serving a general population with confidence that the pARC can be used to reliably estimate appendicitis risk.

Multiple clinical decision tools to aid in the diagnosis of pediatric appendicitis have been described.[41,42] They vary widely in their congruence to published criteria for rigor in clinical decision rules.[22,43] Two of the more well-studied scores include the PAS and Alvarado scores.[8,44–49] Investigations of these tools have shown methodological or performance features that limit clinical application.[20,50–52] Specifically, these tools generally place the majority of patients into intermediate-risk categories that indicate imaging utilization; this is in contrast to the pARC in which the majority of patients are sorted into low- and high-risk categories that could help mitigate imaging utilization. In addition, these decisions

tools have rarely been studied in the setting in which the majority of children present – in community EDs.[21]

Another common shortcoming of clinical decision tools is capturing only a subset of the intended study population. This is frequently seen in studies of pediatric appendicitis which enroll patients already admitted to the hospital or after appendectomy has already been decided upon, far past a point where diagnostic decisions have been made by the initial provider.[49] Such selection biases may miss true appendicitis cases, affect the performance characteristics of the tool, limit its generalizability, and likely contribute meaningfully to the heterogeneity of reported rates of appendicitis.[53] Previous work has demonstrated that our triage identification of patients by a chief complaint of abdominal pain has a sensitivity of 97% for pediatric appendicitis cases presenting to the ED.[54] Many of our study-eligible patients were not enrolled into the CDSS by the physician, possibly due to low suspicion for appendicitis, given this eligible but not enrolled cohort had a very low appendicitis rate of 0.86%. Since our triage identification is highly sensitive and our missed eligible appendicitis rate is very low, we believe we captured the majority of appendicitis cases presenting to the ED during the study period.

Our study adds to the existing literature on this topic in several ways. First, we studied a diverse group of pediatric patients, representative of the spectrum of pediatric patients presenting for acute care in the United States. Second, the discriminatory performance of the pARC was found to be higher than the previously studied PAS. Third, we described how the pARC provided more clinically actionable information than the PAS by stratifying the majority of patients into low- or high-risk strata. Finally, and importantly, the pARC provided these performance characteristics while maintaining patient safety, demonstrated by a negative appendectomy rate of 6.5% and perforation rate of 15.6%, which are comparable to published reviews of pediatric populations.[5,12,55,56]

There are exciting opportunities for further work to improve the pARC. One is to leverage the pARC's dependence on an electronic calculator to allow for dynamic calibration of the score based on the appendicitis prevalence or practice setting in which a patient is being assessed for appendicitis. For example, when initiating the calculator, a user might select an academic children's hospital setting (as in the original validation study) or community setting (as in this study) to set the calibration.[31] Such dynamic calibration is not necessary for utility, as we have shown the pARC's clinically useful performance without it, but it may offer a path to further improve the tool's risk assessment. Other avenues may include risk stratifying patients for antibiotic-only treatment of appendicitis or studying pARC performance in non-ED settings such as urgent care.[57]

In this external validation study of more than 2,000 pediatric patients presenting for care in 11 community EDs, we have shown the pARC safely and accurately assesses appendicitis risk for children aged 5 years and over who may have appendicitis. Further study is needed to understand the impact of pARC on the clinical care of patients with suspected appendicitis.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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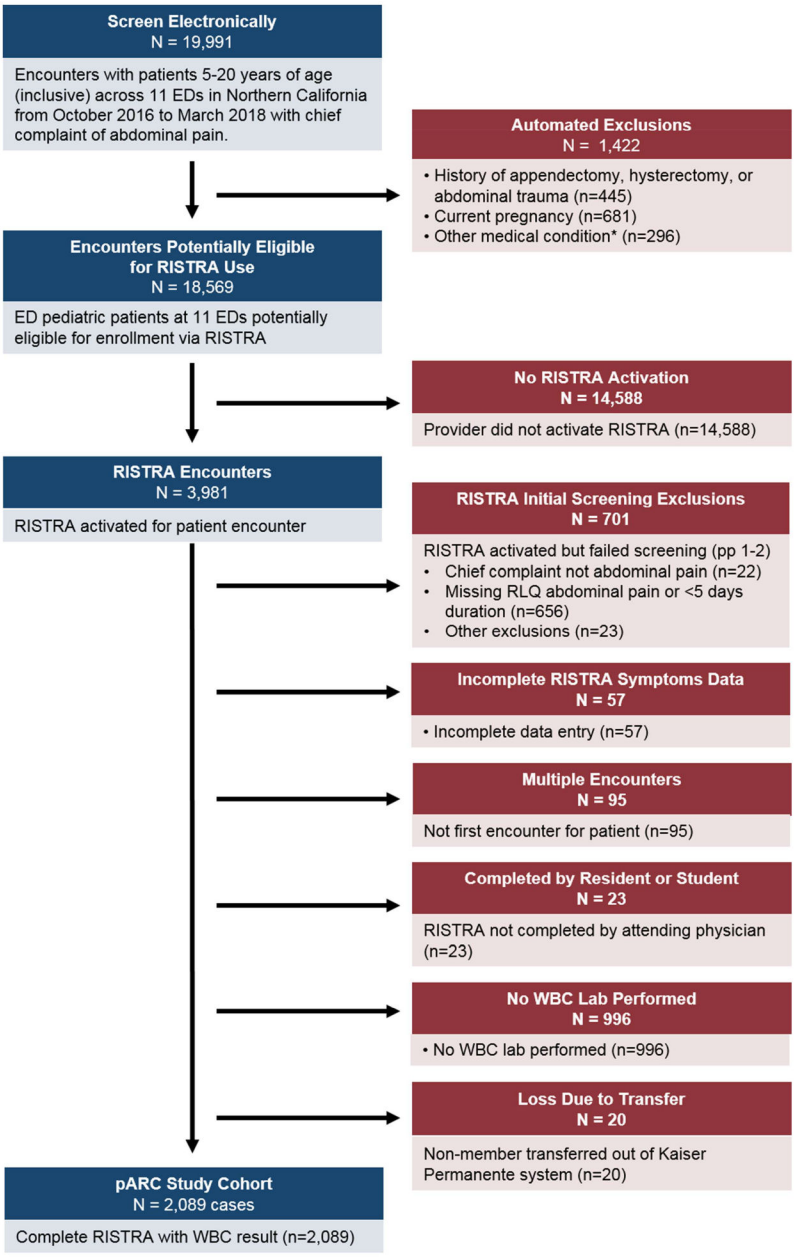

Figure 1.

Flow diagram

pARC = pediatric Appendicitis Risk Calculator, RISTRA = A clinical decision support system RISk STRAtification tool embedded in the electronic health record, RLQ = right lower quadrant, WBC = white blood cell count

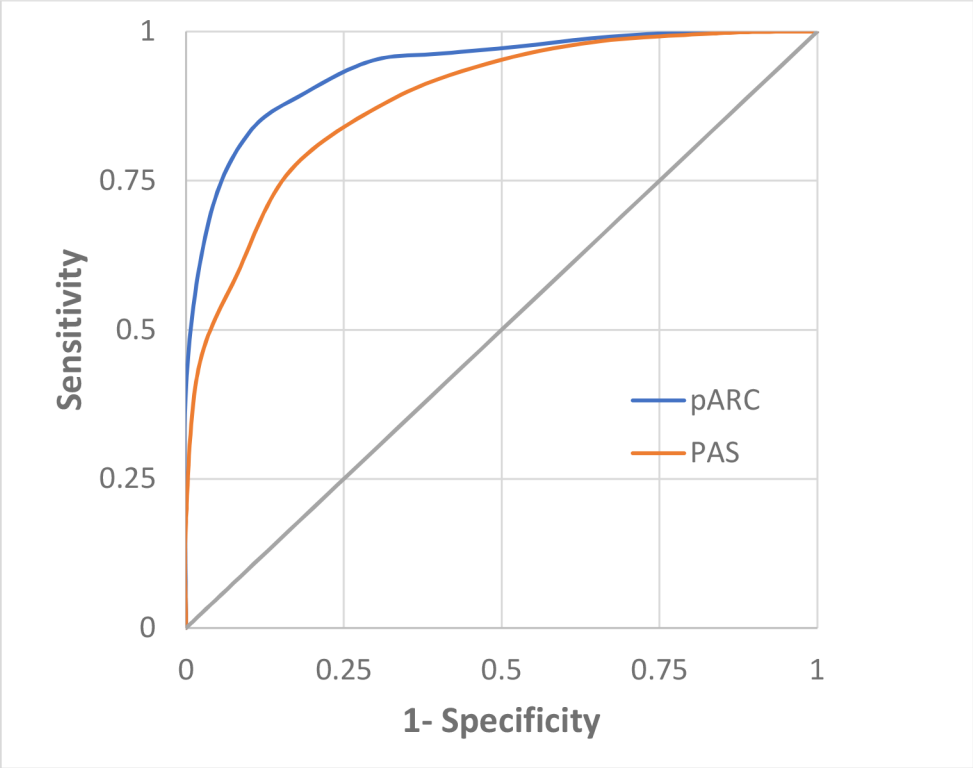

Figure 2.

Receiver operator curve for pARC and PAS

pARC = pediatric Appendicitis Risk Calculator; PAS = Pediatric Appendicitis Score

pARC area under the curve 0.89 (95% CI 0.87–0.92), PAS area under the curve 0.80 (95% CI 0.77–0.82)

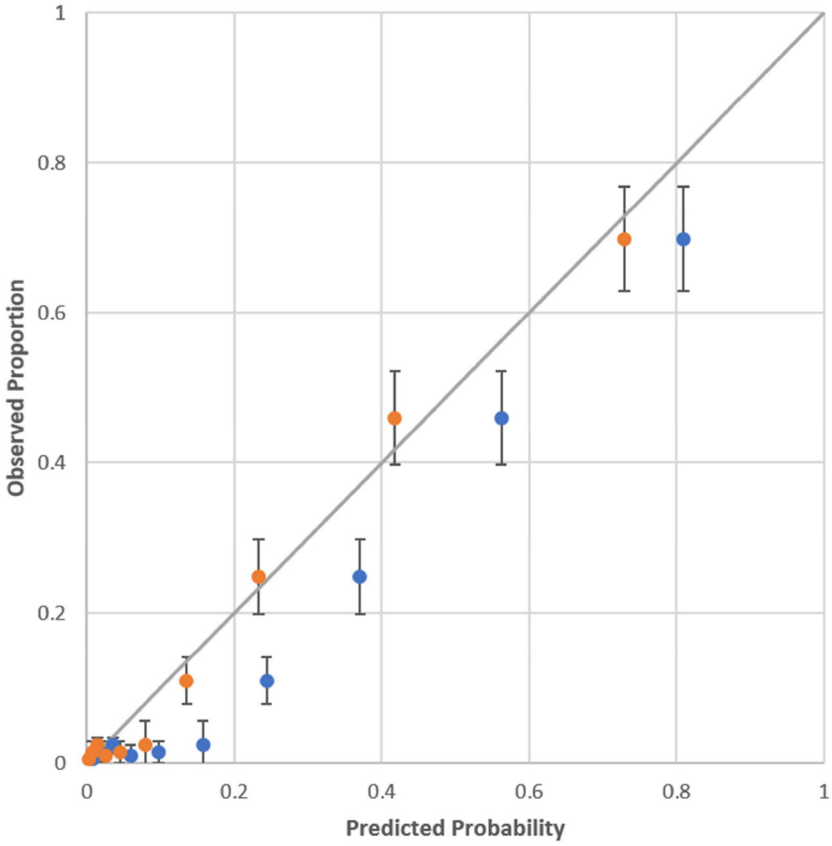

Figure 3.

Calibration plot for pARC

Blue plot is pARC

Orange plot is pARC after calibration

Hosmer-Lemeshow goodness of fit 11.81 (p=0.160)

Calibration intercept and slope on the logit scale was −0.615 (SE 0.76, p<0.0001) and 1.10 (SE .057, p<0.0001)

Table 1.

Study population characteristics

Characteristic	Cohort, n (%) N = 2,089
Median age, y (IQR)	12 (9–16)
Sex and age, y, n (%)	
Male	963 (46)
5–7.9	221 (11)
8–13.9	446 (21)
14–20.9	296 (14)
Female	1,026 (54)
5–7.9	173 (8)
8–11.9	300 (14)
12–20.9	653 (31)
Reported clinical presentation, n (%)	
Duration of abdominal pain, h	
<24	1,179 (56)
24–47	307 (15)
48–120	603 (29)
Nausea or vomiting	1,436 (69)
Pain with walking or hopping	1,004 (48)
Migration of pain to RLQ	660 (32)
Findings on examination, n (%)	
Maximal tenderness in RLQ	1,009 (48)
Abdominal guarding	524 (25)
Median laboratory results (IQR)	
WBC (x10^3/μL)	9.9 (7.5–13.5)
ANC (x10^3/μL)	6.8 (4.43–10.53)
Appendicitis confirmed, n (%)	353 (17)

ANC = absolute neutrophil count, pARC = pediatric appendicitis risk calculator RLQ = right lower quadrant, WBC = white blood cell count

Table 2.

pARC performance and safety outcomes by predicted probability of appendicitis

pARC score*, %		Number of enrollees (% of total)	Appendicitis cases	Appendicitis prevalence, % (95% CI)	Sensitivity†, % (95% CI)	Specificity†, % (95% CI)	Missed appendicitis‡, n (%)	Perforation, n (%)	Negative appendectomy, n (%)
<5%	Very low	661 (32)	9	1.4 (0.5–2.3)	100.0	0	2 (0.3)	0	4 (30.8)
5–14%	Low	462 (22)	14	3.0 (1.4–4.6)	97.5 (95.9–99.1)	37.6 (35.3–39.9)	0	0	4 (22.2)
15–24%	Intermediate	247 (12)	19	7.7 (4.4–11.0)	93.5 (90.9–96.1)	63.4 (61.1–65.7)	1 (0.4)	1 (5.3)	3 (13.6)
25–49%		335 (16)	80	23.9 (19.3–28.5)	88.1 (84.7–91.5)	76.5 (74.5–78.5)	2 (0.6)	10 (12.5)	8 (9.1)
50–74%		230 (11)	115	50.0 (43.5–56.5)	65.4 (60.4–70.4)	91.2 (89.9–92.5)	4 (1.7)	23 (20.0)	3 (2.5)
75–84%		75 (4)	49	65.3 (54.5–76.1)	32.9 (28.0–37.8)	97.8 (97.1–98.5)	0 (0.0)	9 (18.4)	0 (0.0)
>=85%	High	79 (4)	67	84.8 (76.8–92.8)	19.0 (14.9–23.1)	99.3 (98.9–99.7)	1 (1.3)	12 (17.9)	1 (1.5)
Total		2,089	353				10	55	23

pARC = pediatric Appendicitis Risk Calculator

*Predicted probability of appendicitis

†The test result was positive if the score was greater than or equal to the cut point ≥0, ≥5, ≥15, ≥25, ≥50, ≥75, ≥85

‡Missed appendicitis % as missed appendicitis cases per total number of patients in that risk strata

Table 3.

Characteristics of 9 patients with very low pARC scores who were diagnosed with appendicitis

Case number	Age (y)	Sex	Duration of pain (h)	Walking	Migration	Maximal tenderness in the RLQ	Guarding	WBC (ANC)	Perforation	Missed appendicitis	pARC score*, %
1	13	F	<24	No	Yes	Yes	No	7.1 (3.4)	No	Yes	2.1
2	19	M	<24	Yes	No	No	No	5.0 (3.0)	No	No	3.6
3	16	F	48–120	Yes	Yes	Yes	No	5.6 (2.1)	No	No	3.4
4	7	M	48–120	No	No	No	No	6.5 (5.7)	No	No	2.3
5	17	F	<24	No	Yes	No	No	6.9 (3.9)	No	No	0.9
6	19	F	<24	Yes	No	No	No	8.8 (6.3)	No	No	4.0
7	12	M	<24	No	No	No	No	7.0 (4.3)	No	Yes	2.2
8	20	F	48–120	No	Yes	Yes	Yes	7.1 (3.3)	No	No	4.3
9	8	F	<24	No	No	No	No	9.4 (7.2)	No	No	3.7

ANC = absolute neutrophil count, pARC = pediatric appendicitis risk calculator, RLQ = right lower quadrant, WBC = white blood cell count

*Predicted probability of appendicitis

Response Table 1.

pARC validation exclusions

Diagnosis	ICD 9 Code	ICD 10 Code
Sickle cell disease		D57.0-.8xx
Inflammatory bowel disease	555, 555.x, 556, 556.x	K50.x
Cystic fibrosis		E84.x
Acute pancreatitis	577	K85.x
Chronic pancreatitis	577.1	K85.x, K86
Volvulus	560.2	K56.2
Intestinal atresia/stenosis	751.1, 751.2	Q41.8, Q41.9
Hirschsprung's	751.3	Q43.1
Cancer	140–209	C00-C96.Z
Bone marrow transplant	41.0, 41.0x,	T86.00-.09, Z48.290, Z94.81
Lupus	710	D68.62, M32.8-.10, M32.14-.15, M33.19
Henoch-Schoenlein purpura	287	D69.0
Juvenile rheumatoid arthritis	714.3	M08.00–99
HIV	42	B20, B97.35
Mental retardation	317–319	F72, F73
Down's and other chromosomal anomalies	758.x	Q90, Q91, Q92, Q93
Abdominal trauma	863–868	S36, S37, S38, S39
Diverticulitis		K57.x
Ulcerative enterocolitis		K51.0-.3xx
Colitis		K51.5–9x, K52.0, K55
Hysterectomy		N993
ESRD/Dialysis		N18, N19, T82.4x, T85.6x, T85.7x, Y62.2, Y84.1, Z49.x, Z91.15, Z99.2
Transplant (heart, lung, liver, kidney)		T86.1x-.4x
Pregnancy		O00-O99, O9A.x
Appendicitis		K35, K36, K37, K38
Medication Type	**GPI**	
Anti-metabolite	213000, 662500	
Immunosuppressive	994060, 994040, 994020, 994030, 994040, 130000	
Growth factors	824015	
Antiretrovirals	121060, 121050, 121080, 121085	
NRTIs	121090	
Protease inhibitors	121045, 121099	
Others	121025, 121020, 121030, 121099, 121030, 121095	
Cystic fibrosis treatment	512000	
Sickle cell treatment	828030	
Inflammatory bowel disease treatment	525050, 662700, 525000	
Surgical Procedure	**CPT**	
Appendectomy	44950–44979	

ESRD/Dialysis	90918–90999
Cholecystectomy	see intra-abdominal
Colon Surgery	see intra-abdominal
Gastric Bypass	43843–43848
Hysterectomy	58150–58573
Kidney transplant	50220–50380
Liver transplant	47010–47370
Heart transplant	33930–33945
Intra-abdominal surgery	

CPT = current procedural terminology, ESRD = end-stage renal disease, GPI = generic product identifier, HIV = human immunodeficiency virus, ICD= international classification of disease, NRTI = nucleoside reverse transcriptase inhibitors