VALIDITY OF SAMUEL'S PAEDIATRIC APPENDICITIS SCORE (PAS) IN THE DIAGNOSIS OF ACUTE APPENDICITIS IN CHILDREN

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ABSTRACT

Objective: To validate the paediatric appendicitis score for the diagnosis of acute appendicitis in children using histopathology as a gold standard.

Design: Validation study.

Place and Duration of Study: Military Hospital (MH) and Combined Military Hospital (CMH) Rawalpindi, Pakistan from Dec 2009 to Jul 2010

Patients and Methods: Eighty five children 1-17 year old who came to our tertiary surgical department with the chief complaint of abdominal pain of less than 7 days duration were included in the study. Paediatric appendicitis score (PAS) components including fever > 38°C, anorexia, nausea/vomiting, cough/ percussion/hopping tenderness, right-lower-quadrant tenderness, migration of pain, leukocytosis > 10,000 (10^9/l) and polymorphonuclear - neutrophilia > 7500 (10^9/l) were assessed and recorded on admission, but the sum was not calculated until later and the score did not play any role in the management of the patient. The diagnosis of appendicitis was made by the trainees and consultants clinically and with the aid of routine sonography of abdomen. After appendicectomies, resected specimens were sent for histopathological examination. Pre-operative PAS, and histopathology report of resected appendix were endorsed on patient's performa. A two by two table was used to determine sensitivity, specificity, positive and negative predictive values and diagnostic efficacy of PAS.

Result: Sensitivity of PAS was 92.16%, specificity 88.23%, positive predictive value 92.16%, negative predictive value 88.23% and the diagnostic efficacy 90.59%.

Conclusion: PAS is a highly sensitive test with fair degree of specificity in diagnosing acute appendicitis in children and its routine usage may improve the diagnostic accuracy.

Keywords: Appendicitis, Appendicitis score, Children.

INTRODUCTION

Appendicitis, the most common pediatric surgical emergency, is defined as the inflammation of vermiform appendix. Life time incidence of acute appendicitis is 7%[1]. The importance of diagnosing appendicitis early enough that perforation is avoided while minimizing the number of negative appendectomies that are performed is widely recognized. Becker et al found that 44% of patients diagnosed with appendicitis presented with 6 or more atypical features[2]. The investigation of patients with possible appendicitis varies widely between hospitals and countries, and there are many conflicting recommendations within the international literature (blood counts, ultrasonography, CT/MRI scans)[3-5]. Risk of perforation increases significantly 24 hours following admission[6].

Appendicitis occurs in all age groups but the diagnosis of appendicitis in younger children is more difficult because of the patients' inability to clearly express their symptoms and overlap of signs and symptoms with other common childhood illnesses. This is evident by the fact that rate of appendiceal perforation is 80-100% for children younger than 3 years compared to less than 10-20% for children aged 10-17 years[7]. On the other hand, 10%–30% of all patients undergo surgery unnecessarily, with a false positive diagnosis of appendicitis[7]. The search of the perfect diagnostic tool has been

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unsatisfactory. Clinical and computer-aided scoring systems have been shown to increase the diagnostic accuracy and reduce unnecessary appendicectomies in adults[8]. However, diagnostic scores abstracted from adults data have not been found to be useful in children[9]. Samuel, in 2002, proposed one such numerically based system for the diagnosis of acute appendicitis in children which is called pediatric appendicitis score (PAS)[9].

The pediatric appendicitis score is based on eight variables, each of which is assigned a score to get a total score of 10 (table-1). Samuel recommended that a score less than or equal to 5 should be observed, and a score greater than or equal to 6 should undergo surgical consultation. This score, according to Samuel, had a sensitivity of 1, specificity of 0.92, positive predictive value of 0.96, and negative predictive value of 0.99. This was exceptional performance for a diagnostic score and, as a result, has the potential to be a superior alternative to imaging with CT and ultrasound. Since abdominal pain is one of the most common presenting complaints to pediatric emergency departments, having a tool that could reliably differentiate appendicitis from the numerous other less acute causes would be extremely valuable from a clinical standpoint. Although this score has been validated by several researchers in the West but no local studies are available at present.

The rationale of doing the study on this topic was that CT/MRI are expensive and not readily available everywhere so these investigations couldn't be used routinely for the diagnosis of acute appendicitis in children. On the other hand PAS is easy to apply on patients and involves only two very easily available and cheap investigations. If this score is found to be effective in our population as well, it will, on one hand, significantly reduce the complications of acute appendicitis in younger age and on the other hand it will also reduce the number of negative appendectomies.

PATIENTS AND METHODS

After approval from hospital ethics committee, 85 children, 1-17 year old, who came to the tertiary care surgical department with a chief complaint of abdominal pain of less than 7 days duration were recruited. Patients with previous history of appendectomy and those referred with a known cause of abdominal pain were excluded from the study. Informed written consent was taken from the parents or guardians. PAS components including fever > 38°C, anorexia, nausea / vomiting, cough/ percussion/ hopping tenderness (2-points), right-lower-quadrant tenderness (2-points), migration of pain, leukocytosis > 10,000 (10^9/L) and polymorphonuclear-neutrophilia > 7500 (10^9/L) were assessed . The elements of the score were recorded in each patient on admission by 2nd year/ 3rd year post graduate trainee surgery, but the sum was not calculated until later and the score played no role in the management of the patient. The diagnosis of appendicitis was made by trainees clinically and with the aid of routine sonography of abdomen which was further verified by consultants before appendicectomy. After appendicectomies, resected specimens were sent for histopathological examination to consultant pathologist at AFIP/Army Medical College pathology laboratory. Pre-operative PAS and histopathology report of resected appendix were endorsed on the patient's performa.

All data collected through the performa was entered into the statistical package for social sciences (SPSS) version 13.0 and analyzed.

Mean and standard deviation were described for quantitative data like age while frequency and percentage were calculated for qualitative data like gender. The PAS was applied to each patient's data and two by two table was used to determine sensitivity, specificity, positive predictive value, negative predictive value and accuracy. ROC curve was drawn and AUC and *p*-value were calculated. (figure-1)

RESULTS

Age and Sex

The mean age and standard deviation (SD) was 13.07 + 3.05 and sex ratio (male to female) was 1.44: 1.

Pathology

Fifty one of eighty five cases (60%) had appendicitis confirmed by histology. Pathologic stages of acute appendicitis included acute appendicitis 25 cases (29.4%) of acute appendicitis, 18 cases (21.2%) of acute appendicitis with pre-appendicitis, 5 cases (5.9%) of acute supporative appendicitis is gangrenous appendicitis.

In 34 (40%) out of 85 cases the histopathology was other than acute appendicitis like lymphoid hyperplasia 17 cases (20%) idiopathic cases of pain abdomen in which histopathology showed congestion of appendix 16 cases (18.8%), and Meckel's diverticulum 1 case (1.2%).

Validation of PAS

The statistical analysis of the study was done using a 2 x 2 table for comparison of PAS with histopathological diagnosis of appendix (table-2). These figures are based on the data of 85 patients. Sensitivity of PAS was 92.16%, specificity 88.23%, positive predictive value 92.16%, negative predictive value 88.23% and the diagnostic efficacy 90.59%, (table-3).

In our study all 85 cases were diagnosed as acute appendicitis without using PAS. However post operative histopathology revealed acute appendicitis only in 51 cases (60%) showing negative appendecectomy rate of 40%. If we apply PAS to these patients, negative appendicectomy rate will decrease to 4.7% (4 out 0f 85) and 4.7% (4 out of 85) patients with appendicitis would have been missed diagnosis, (table-2).

DISCUSSION

In this validation study of PAS using a sample of 85 children aged 1 to 17 years, presenting in emergency surgical department of MH and CMH Rawalpindi, with abdominal pain

Table-1: Pediatric appendicitis score (PAS).

Diagnostic indicants	Score value
Cough on percussion or hop tenderness	2
Anorexia	1
Pyrexia	1
Nausea / emesis	1
Tenderness in RLQ	2
Leukocytosis > 10,000	1
Polymorphonuclear Neutrophilia	1
Migration of pain	1
Total	10

Table-2: Accuracy of pediatric appendicitis score (PAS) in diagnosis of acute appendicitis.

		Histopathology of appendix		
		Inflamed appendix	Normal appendix	
PAS	> 6	True positive	False positive	51
		47	04	
	< 5	False negative	True negative	34
		04	30	
		51	34	85

Table-3: Diagnostic accuracy of pediatric appendicitis score (PAS) (n=85).

Diagnostic accuracy	Percentage
Sensitivity	92.16
Specificity	88.24
Positive predictive value	92.16
Negative predictive value	88.23
Diagnostic accuracy	90.59

suggestive of acute appendicitis, we were unable to reproduce the same good results as claimed by Samuel in 2002. There are several reasons for it.

First of all, Samuel has shown the sensitivity of PAS to be 1 and specificity 0.92 at a single cut point (PAS < 5 = no appendicitis and PAS > 6 = appendicitis) but these values are likely to be overestimated as they were obtained from

derivation data set. This score was developed on the same population that it was applied to, which generally results in over estimation of accuracy of score. This is further confirmed by the fact that Samuel himself validated his PAS score over a population of 66 children. Results of this study are provided as addendum to his article but he himself was unable to reproduce the results of his derivation study in his validation study. He reported the score having sensitivity 1, specificity 0.87, PPV 0.9 and NPV of 1. But only children with PAS < 5 and PAS > 8 were included in this calculation and there was no mention of the diagnosis of children with score 6 and 7.

Secondly, Samuel did not provide absolute definitions of pyrexia and polymorph onuclear neutrophilia. There are numerous temperature thresholds that could be interpreted as pyrexia and wide variation of percentages that could be considered to qualify as neutrophilia. In this study a temperature of >38^{0}C was used as pyrexia and > 75% neutrophils as neutrophilia in our study. This lack of definition is especially problematic as it does not allow for exact replication of score in further studies and may have resulted in variations in results of our study and the original Samuel study.

Thirdly, the duration of time that historical items (like nausea/emesis and anorexia) could be present and qualify as being related to the symptoms is not specified. For example, if a child had an episode of nausea 4 days back and now he presented with new onset abdominal pain , does this symptom qualify for inclusion in the score?

In another study, Schneider and her colleagues[10] prospectively validated PAS. Data was collected by emergency medicine physicians. Final diagnosis was obtained by histopathology report if patient was operated for appendicitis or a follow up call 2 weeks after discharge if patient had not undergone surgery. Thirty four percent patients had appendicitis and eighteen percent were perforated. Using a cutoff point of < 5 as suggested by Samuel, sensitivity was 82%, specificity was 65%, NPV 86% and PPV of 54%. These results are not comparable to the results of our study. This difference in result may be because schneider and his colleagues applied this scoring system to a population with a very low probability of disease. This was reflected in much lower prevalence of disease (34%) in Samuel's study (63%) as compared to our study (58%).

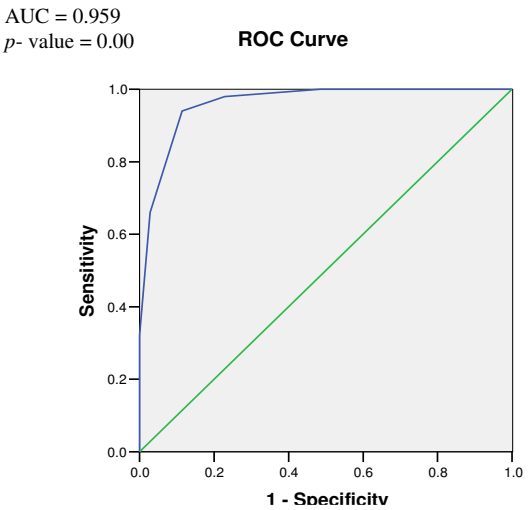

Figure-1: ROC Curve, AUC and *p* - value

Coordinates of the curve

PAS	Sensitivity	1 - Specificity
1.0000	1.000	1.000
2.5000	1.000	0.824
3.5000	1.000	0.471
4.5000	0.980	0.206
5.5000	0.922	0.118
6.5000	0.647	0.029
7.5000	0.314	0.000
8.5000	0.020	0.000
10.000	0.000	0.000

Another potential limitation is that the author excluded all patients who did not have any follow up. Follow up was done in one of the several ways. They first attempted to contact the child's parents / guardians, if not available, then patients physician was contacted. If both were not available then hospital record was reviewed.

This method of follow up is problematic as child's physician may not know the final outcome if patient sought care from an alternative location. In this sense follow up was not complete.

In another study, Canadian investigators prospectively validated PAS[11]. PAS > 6 was cut off point for surgical intervention, similar to our study and like original description of PAS by Samuel there results showed sensitivity of 92.8%, specificity 69.3% and accuracy of 89.5% but with unacceptably high rate of negative appendectomies (37.6%).

In order to reduce negative appendectomy rates, author proposed two cut off points i.e., < 4 PAS to discharge patients and PAS > 8 for appendectomy. Further investigations were recommended for scores 5 to 7. With this strategy sensitivity improved to 97.6%, specificity 95.1%, negative predictive value 97.7% and positive predictive value 85.7% with negative appendectomy rate reduced to 8.8%. These results were not comparable with our results because they used groups of children who were enrolled in the study at physician's discretion. This may have resulted in over representation of equivocal cases in sample decreasing sensitivity and specificity.

PAS was retrospectively validated by Goulder and Simpson at Kent and Sussex hospital UK[12]. Using cut off point of > 6 for surgery and < 5 to discharge patient, there results showed sensitivity of 0.87, specificity of 0.59, positive predictive value of 0.87 and negative predictive value of 0.67. Difference in results of this study may be due to the facts that sample size in this study was quite small (56 patients only), score elements were abstracted from the medical record and there was no mention of missing data and reliability of the variables could not be assessed due to retrospective nature of design.

In all the studies mentioned above, except our study, the score has not yet been validated in a population that is similar to the one in which Samuel derived the score. It was validated in different populations of children and in the hands of medical physicians instead of surgeons. This has resulted in varying results different from Samuel. Our study was the first one in which the score was validated in the hands of surgeons and in children with high probability of appendicitis similar to the study of Samuel. This is probably the reason that our results are relatively closer to Samuel's results as compared to the rest of studies mentioned above[10-12].

Limitations

In our study, following limitations were observed.

This score contains many subjective pieces of information from history and physical examination and without assessment of interobserver reliability, reproducibility of findings is unknown.

Study was carried out at Armed Forces hospitals which cater mainly for service personnelle and their families. It may not truly represent the "whole" population.

We included only those patients in our study which were actually operated upon and did not include those patients presenting with pain abdomen but sent home on the basis of clinical assessment.

CONCLUSION

PAS is a simple and relatively accurate diagnostic tool which can be applied in children presenting with abdominal pain suggestive of acute appendicitis. It can be effectively used as a guide to assist in deciding whether to operate or observe a child with abdominal pain. We suggest a cut off value of 5 in our population because at this value PAS on one hand effectively reduce negative appendectomies and on the other hand only few cases with actual diagnosis of appendicitis are missed.

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