Original research article

The relationship between Alvarado Score and Pain Score in Managing Adult Acute Appendicitis in the Emergency Department

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Abstract

Acute appendicitis is one of the most common differential diagnoses for acute abdominal pain made by emergency doctors. Suspected cases require surgical referral for observation or definitive intervention to prevent complications. A high index of suspicion and good clinical skills with the aid of scoring systems allows early decision making, which includes optimal pain control. The objective of this study was to identify the pain score and is relationship to the cut-off points of the Alvarado scoring system so that justifies early surgical referral or discharge for suspected acute appendicitis from the Emergency Department of Universiti Kebangsaan Malaysia Medical Centre (UKMMC). This was a cross sectional study of acute abdominal pain from June 2007 to September 2008. All patients who fulfilled the criteria and consented to the study were assessed for Alvarado score, verbal numerical pain score (VNRS) and their subsequent management. Patients with an Alvarado score of ≥7 were likely to have acute appendicitis (80.1% sensitivity and 52.63% specificity) and those with the score of ≤3 were unlikely to have acute appendicitis. The median pain score was 7.00 (IQR: 5.00-8.50) but 72.5% did not receive any analgesia. There was no direct relationship between the pain score with Alvarado score. Oligoanalgesia in patients with acute appendicitis still exist in Emergency Department of UKMMC.

Keywords: Abdomen, acute, appendicitis, analgesia, emergencies, pain measurement,

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Introduction

Acute appendicitis classically presents with gradual development of central abdominal pain, with subsequent localisation to the right iliac fossa and often with nausea and vomiting. Reginald H. Fitz, a Harvard pathologist in 1886, first reported the signs and symptoms of acute appendicitis (1). He suggested that localised rebound tenderness and signs of peritoneal inflammation would make the diagnosis more probable.

The provisional diagnosis of acute appendicitis was essentially based on clinical judgment. Unfortunately, due to the anatomical variation of the appendix and thus its presentations, decision-making can be difficult. In the early phase of the disease progression, not all patients present with the classical signs and symptoms (2,3). Doctors in the Emergency Department (ED) may find it difficult to diagnose acute appendicitis with confidence based on clinical grounds alone (4,5). Thus a scoring system, used as a diagnostic tool, may help to determine earlier and more convincingly, the group of patients who will require further investigation and serial observation in the ward or urgent appendicectomy (5,6).

Serial pain scoring may indicate the group of patients that requires analgesia. With a scoring system such as the Verbal Numerical Rating Score (VNRS), the risk of psychological and physical stresses from suboptimal pain management can be reduced.

The main objectives of this study were to identify the cut-off point of the Alvarado Scoring System that justifies early surgical referral for suspected acute appendicitis from the ED and its relationship with pain score using the VNRS. The authors also looked at whether analgesia was adequately given to patients with VNRS of five and above which represents moderate to severe pain.

Materials and methods

This was a cross sectional study with data collected from 1 June 2007 to 30 September 2008. Ethical approval was obtained prior to data collection from the Universiti Kebangsaan Malaysia Medical Faculty Ethics Committee. All patients who presented with acute abdominal pain to the ED, Universiti Kebangsaan Malaysia Medical Centre (UKMMC) and those who fulfilled the inclusion criteria were invited to participate.

The inclusion criteria were:- all patients aged twelve years old and above who were categorized as adult surgical admission, presented to ED with acute abdominal pain of less than 72 hours and were given a differential diagnosis of acute appendicitis by the Emergency (ED) doctors. The exclusion criteria were:- a Glasgow Coma Scale (GCS) of less than 15/15, resuscitated or intubated patients, pregnant female patients, suspected Acute Coronary Syndrome (ACS), chronic abdominal pain secondary to other causes and trauma or polytrauma patients that may also complain of abdominal pain.

The primary triage officers first screened all patients who came during the data collection period. They then registered all patients with acute abdominal pain after further assessment in the secondary triage. Following a waiting period, they were subsequently seen and assessed by the emergency doctor. Full blood count and urine were taken in the secondary triage or the procedure room as part of the department protocol of managing acute abdominal pain and the test results were reviewed. All patients who were provisionally diagnosed with acute appendicitis and fulfilled the inclusion criteria were invited to participate in the study. The study form was filled up and the necessary investigation results recorded. After a verbal explanation and reading the study information sheet, all patients who agreed were requested to sign the informed consent form.

From the history, physical examination and investigation results, the Alvarado score was calculated. The pain character and intensity were also recorded using the Verbal Numerical Rating Scale (VNRS) with zero indicating ‘no pain’ and ten indicating ‘the worst pain imaginable’. At the same time, each patient with provisional diagnosis of

acute appendicitis was referred to the surgical team for further management. The histolopathological reports of surgical samples from those who underwent surgical intervention were reviewed and recorded. All patients who were enrolled but were discharged by the ED doctor or by the surgical team without undergoing surgery were verbally advised to return to ED of UKMMC if the problem persisted or worsened. They were also followed up via telephone call within two weeks from the point of discharge and their progress noted.

Statistical analysis

All gathered data were statistical analyzed using the Statistical Package of Social Studies (SPSS) version 15.0 for Windows and reviewed by a clinical statistician.

Results

There were initially 45 patients who gave consent for enrolment, but only 40 were analyzed after five participants had to be excluded due to delayed presentation to the ED and incomplete or undocumented data in the patient study forms. The age ranged between 13 years to 63 years with the median age of 24.50 (IQR: 19.00-29.75) years. There were 65% (n=26) males participants with the median age of 27.00 (IQR: 20.75-31.50) years and 35% (n=14) females participants with the median age of 20.00 (IQR: 17.00-25.75) years old.

The average presentation time of acute abdomen pain was 1.0 (IQR: 1.00-2.00) days. The average waiting time for 39 participants prior to be seen by the ED doctor was 60 minutes. One participant was excluded from the data analysis, as the time seen by the ED doctor was not documented. There are 13 (32.5%) patients who did not undergo surgery (Table 1). Five patients were discharged from the ED. Of these, three patients were discharged by the ED doctors without surgical referral and two patients by the surgical doctors after a referral. The two patients were admitted to the ED observation ward and were reviewed by the surgical team prior to discharge. Another eight were admitted to the surgical ward but were subsequently discharged

Table 1: Alvarado score of suspected acute appendicitis in ED UKMMC and the outcome

Alvarado score	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Total patients	0	2	3	0	4	5	5	10	7	4	40
Discharged from ED	0	1	1*	0	1	0	1	1*	0	0	5
Admitted to Ward	0	1	2	0	3	5	4	9	7	4	35
Surgical intervention	0	1	1	0	3	2	3	7	6	4	27
Post-op Dx appendicitis	0	1	1	0	3	2	3	7	6	4	27
Histologic Appendicitis	0	0	1	0	2	1	3	4	6	4	21
Histologic Normal	0	1	0	0	1	1	0	3	0	0	6
No Histo sample	0	1	2	0	1	3	2	3	1	0	13

*Patients discharged by the surgical team after reviewing in ED

without an operation. Follow up phone calls were made and all participants were noted to be well with no surgical intervention required or any persistence of pain for them to seek medical assistance. There was zero percent (n=0) missed appendicitis in this study data.

In order to choose the optimal cut-off for this scoring system, a receiver operating characteristic (ROC) curve was plotted (Figure 1) and the test result variables listed in Table 2. The graph showed the plotted line fell just to the left of the diagonal line with the coordinates being in the area under the curve (AUC) 75.4% of the time thus this meant that the scoring system under investigation was applicable or usable.

In order to investigate the optimal cut-off point from the data collected, the score five was taken as the score that suggest possible acute appendicitis based on the initial study by Alvarado. From this information, the number of patients with the score of five and above and patients with scores less than five was cross-tabulated to the final diagnosis to generate the figures in Table 3. Subsequently the estimates of measures of interest were calculated and summarized in Table 4.

Therefore, at the cut-off point score five, a high-test sensitivity of 95.24% is noted at the expense of its specificity of only 21.05%. The positive likelihood ratio (LR) of 1.20 indicated that cut-off score five was not significantly useful as a definitive diagnostic score where at this point, true acute appendicitis was only 1.2 times more likely to occur in an individual provisionally diagnosed with the disease than in one without the disease. From the ROC curve, a cut-off score six had a sensitivity of 85.71% and specificity of 31.16%. Similarly, Alvarado score seven had a sensitivity of 80.1%, specificity of 52.63%, positive predictive value (PPV) of 65%, negative predictive value of 71.0%, likelihood ratio (LR) of 1.691 for the positive result and LR of 0.378 for the negative result.

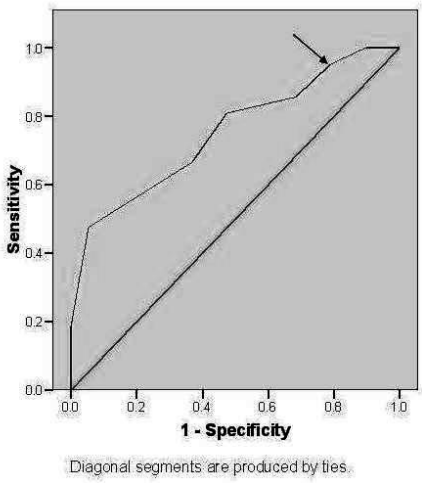

Fig 1: Receiver operating characteristic (ROC) curve with the initial cut-off score of five. A cut-off score of 5 (→) has a sensitivity of 5.24%, specificity of 21.05% and LR of 1.2.

Positive if Greater Than or Equal To (a)	Sensitivity	1 – Specificity
1.00	1.000	1.000
2.50	1.000	0.895
4.00	0.952	0.789
5.50	0.857	0.684
6.50	0.810	0.474
7.50	0.667	0.368
8.50	0.476	0.530
9.50	0.190	0.000
11.00	0.000	0.000

Table 2. Test result variable(s): Alvarado score has at least one tie between the positive actual state group and the negative actual state group

(a) The smallest cut-off value is the minimum observed test value minus 1, and the largest cut-off value is the maximum observed test value plus 1. All the other cut-off values are the averages of two consecutive ordered observe test values.

Table 3: Final diagnoses of acute appendicitis cross-tabulation Alvarado score five.

Alvarado Score	Final diagnosis of appendicitis (from follow up and histopathology report)		
	YES	NO	Total
5-10	20(57.14%)	15(42.86%)	35(100%)
<5	1(20%)	4(80%)	5(100%)
Total	21(52.50%)	19(47.50%)	40(100%)

An Alvarado score of less than five had a high negative predictive value of 80% with the prevalence of the disease was 52.5%. The negative result as represented by a negative LR of 0.23 was relatively close to approaching the value 0. This means the score of <5 may be useful to rule out someone without acute appendicitis. To identify the lowest cut off point that would satisfactorily rule out acute appendicitis, the ROC The curve was again reviewed and a new tabulation for the lowest Alvarado score was similarly calculated (Table 5). The score three had a high sensitivity of 92.86% but very low specificity of 25.0%. The positive predictive value was 74.29% but the negative predictive value was rather high at 60.0%, with the negative LR of 0.29.

The rate of normal appendix histopathology reports was 25% (n=7). Of these, two (7%) patients were diagnosed with other pathological abnormalities other than an acute appendicitis. This meant 17.86% (n=5) of patients who were clinically diagnosed with appendicitis by the surgeons underwent surgery with normal appendix.

All participants complained of abdominal pain on arrival to the ED with the VNRS median of 7.00 (IQR: 5.25-8.75). Among those provisionally diagnosed with acute appendicitis (n=37) the initial VNRS was 7.00 (IQR: 6.00-9.00). The VNRS of those not diagnosed as appendicitis (n=3), the score was also 7.00 (IQR: 6.00-7.00). Using Mann-Whitney test, there was no significant correlation, $p>0.05$ (MW Z score = -1.074, $p=0.283$) between the severity of pain and the provisional diagnosis of acute appendicitis in this ED.

Even though all participants had pain, only 27.5% (n=11) received analgesia while in the ED and 72.5% (n=29) did not. The median VNRS score for those who received analgesia was 8.00 (IQR: 7.00-8.50). The median VNRS score of those who did not receive any analgesia in ED was 7.00 (IQR: 5.00-8.50). The pain characteristics varied between the participants with four (10%) described it to be more than one character and one was not documented(Figure 2).

Discussion

Acute appendicitis may be triggered off by an obstruction of the appendix lumen either from food matter, adhesions or lymphoid hyperplasia (7). Continuous mucosal secretion causes the intraluminal pressure to rise, starting a chain reaction that lead to bacterial invasion by the intestinal flora, inflammatory response and edema (7). The initial luminal distention will trigger the visceral afferent pain fibers that enter the spinal cord at the level of the tenth thoracic vertebrae (7). This is interpreted as vague pain that is poorly localised around the epigastric or periumbilical area. As the pathology progresses, the serosa and adjacent structures to the appendix will be inflamed and this triggers the somatic fibers that localise pain in the right lower quadrant of the abdomen (7).

Alvarado established a practical scoring system for the screening and early diagnosis of acute appendicitis in 1986 where a retrospective study was conducted on 305 patients hospitalized with abdominal pain suggestive of acute appendicitis (6). Signs, symptoms and laboratory findings were analysed for specificity, sensitivity, predictive

Table 4: The estimates of measures of interest by taking Alvarado score five as the cutoff point.

Measures of interest	Calculation	Result
Prevalence	(21/40) x 100% =	52.50%
Sensitivity	(20/21) x 100% =	95.24%
Specificity	(4/19) x 100% =	21.05%
Positive predictive value	(20/35) x 100% =	57.14%
Negative predictive value	(4/5) x 100% =	80.00%
Likelihood ratio for positive result	0.9524/(1-0.2105) =	1.20
Likelihood ratio for negative result	(1-0.9524)/0.2105 =	0.23

value, and joint probability (multivariate logistical analysis). Eight predictive factors were identified and their importance, according to individual diagnostic weight, was determined based on the sensitivity and specificity of each factors. These factors were localised tenderness in the right lower quadrant, leucocytosis, migration of pain or shifting pain to the right lower quadrant, fever, nausea or vomiting, anorexia or acetone in the urine and direct rebound pain (6). The highest total score was 10. Score <5 was less likely, score 5 or 6 was possible, score 7 or 8 was probable and a score >8 was very probable to be appendicitis.

Several studies have attempted to incorporate Alvarado score in various pre-hospital or in hospital settings. Earlier researchers conducted a re-evaluation study of ten different scoring systems to fulfill four standardized criteria (8). They found that only the Alvarado score fulfilled all four criteria.

It was noted that a high Alvarado score in adult male and children provided an easy and satisfactory aid for the early diagnosis of acute appendicitis, but not in the female population, which presented with high false positive results (9,10). For that, other diagnostic tools such as CRP level, ultra sound, CT abdomen and laparoscopy were used in order to reduce the rate of negative appendicectomy that is also known as ‘white’ appendicectomy (11,12,13,14,15).

One of the setbacks of applying the original Alvarado scoring system was the incorporation of laboratory results as part of the scoring system (9). Many practitioners also used a modified version of the Alvarado score because in remote, suburban, or poorly equipped primary care or medical centers, the laboratory test may take a long time to obtain or the facility for such laboratory test was not available. Some centers may not have the immediate facility or capability to determine the Neutrophilic left shift that requires a full blood picture investigation. Instead, the percentage rise of Neutrophils was used to indicate the presence of an inflammatory process and incorporated into this scoring system. Earlier researchers also noted this finding in their local settings where it reflected the geographical and ethnic variability in the accuracy of modified Alvarado scoring system to diagnose a probable acute appendicitis (16). However, in all of these studies, higher scores were shown to have discriminatory values across all ages for the diagnosis (16,17,18,19,20).

To reach a specific diagnosis of the cause of an acute abdomen can be very difficult and humbles even the most experienced medical practitioner. The gold standard test to determine whether one has acute appendicitis or not is by surgically removing the appendix and analysing the histology. Thus, it was

Table 5. The estimates of measures of interest by taking various Alvarado scores as the cutoff point

Measures of interest	Alvarado Score		
	3	6	7
Prevalence	70.00%	52.50%	52.50%
Sensitivity	92.86%	85.71%	80.10%
Specificity	25.00%	31.16%	52.63%
Positive predictive value	74.29%	58.06%	65.00%
Negative predictive value	60.0%	66.67%	71.00%
Likelihood ratio for positive result	1.24	1.25	1.691
Likelihood ratio for negative result	0.29	0.46	0.378

impractical to do this to all patients who were provisionally diagnosed with acute appendicitis. A simpler less invasive test would be more acceptable to provide a reasonable guide to determine if a patient is having the disease or not by the emergency doctors (21). The Alvarado scoring system was identified as a useful clinical tool because it is readily available, extremely affordable, and relatively accurate especially in interpreting the extremes of the score range. The aim in the emergency setting is to have a screening tool with high sensitivity because one would not want to miss acute appendicitis, as it is a treatable disease by relatively uncomplicated surgical procedures.

The distribution of Alvarado scores in this study was not normal. A two by two table of frequencies was drawn and used to ascertain the sensitivity and specificity of the scores. By plotting the ROC curve, a range of scores could be analyzed. One would prefer to have a sensitivity and specificity that were both close to 1 (or 100%). A high sensitivity and high specificity test would be ideal but from the ED management point of view, it is more important to aim for a high sensitive test with moderate specificity. It is better to admit and review these patients rather than unscrupulously discharging them with a possibility of catastrophic complications.

From this study, an Alvarado score of seven was shown to have a strong statistical evidence to be reliably adopted as the acceptable cut-off point for urgent admission to the surgical ward for consideration of a definitive surgical intervention. It was ascertained that the score seven has a high sensitivity with a relatively better specificity of more than 50%.

This also meant that there was a higher chance of missed diagnosis for those with a score of less than seven. For patients who presented with scores of four to six, an early surgical referral with admission to the surgical ward is recommended. These patients should be monitored closely with serial abdominal

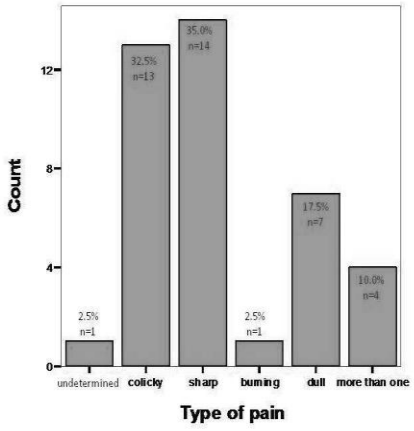

Fig 2: Acute abdominal pain characteristics described to ED doctors.

examination to detect an evolving pathology. They may be subjected to further investigations such as ultrasound or CT scan of the abdomen (22,23). Worsening of the condition or an increasing trend of the Alvarado score during these serial examinations should indicate a consideration for definitive intervention. With the advent of modern laparoscopic surgical techniques, a high rate of detection for true acute appendicitis can be achieved.

There was a relatively strong statistical evidence for those patients with scores of three and below not to have acute appendicitis. They can be observed in the ED ward or if it was agreeable to the patient, discharged home with verbal and written advice. All patients discharged without reaching a diagnosis should be termed "acute abdominal pain of unknown origin" rather than "to rule out acute appendicitis".

There was no correlation found between the severity of pain measured using the VNRS and the Alvarado score. The pain scores were also found to be skewed in its distribution. A high pain score may not be associated with a high Alvarado score. Pain and pain score, such as the VNRS, should then be managed as a separate entity in the treatment of acute appendicitis in the ED.

It is noted that oligoanalgesia persisted in patients provisionally diagnosed with acute appendicitis in the ED. The rate of participants receiving analgesia was low even though the minimum VNRS of 5/10 was met reflecting moderate pain eligible for a more vigorous pain control measures. Analgesia was traditionally withheld from patients presented with acute abdomen. This practice may originate from unsupported remarks that argued that narcotics would obscure the etiology of abdominal pain and mask the need for laparotomy. However, there was increasing evidence to suggest the administration of opioids to patients with abdominal pain was not only safe, but may also aid the diagnosis process (24). Analgesics may facilitate the history taking and physical examination by reducing the patient anxiety and relaxation of the abdominal musculature. Small doses of opioids such as Morphine Sulphate intravenously titrated to control pain were unlikely to conceal a surgical emergency (24). However, patients given narcotics for abdominal pain should not be discharged simply because their pain resolved. In such a patient, serial ED physical examinations, laboratory and radiological studies, and possibly a four hourly review in the ED observation ward may be the next step in the management (depending on the policies of ED observation ward). The issue of inadequate pain management in ED needs to be readdressed and this topic should be included in the refresher courses for new ED medical personnel. The serial use of VNRS for the quantification of the perception of pain and its reflection for adequacy of acute pain control should be encouraged at all levels of patient care in UKMMC.

Based on the histopathological report there was apparently a high rate of the so-called 'white' appendix post surgery, but this result may not be accurate due to the small sample size. The acceptable rate was below 15% but this value may differ from center to center depending on the quality assurance target set by individual establishment (8). To the best of our knowledge there are no previous studies which have been conducted in UKMMC regarding this issue.

This study had limitations of having only a small sample size which may have affected the power of the study. Thus, this study should be continued both to improve the statistical strength of the Alvarado score cut-off point for early surgical referral and the outcome of acute appendicitis in UKMMC. The use of the questionnaire and enrollment of patients was also limited due to lack of awareness about the ongoing study especially in the earlier months of data collection period. This was aggravated

by the high turnover of doctors from various backgrounds working as locums or attachments in the ED.

Conclusion

Based on the statistical evidence, two cut-off points from the scoring system were identified for the management of provisional diagnosis of acute appendicitis in the ED. There was no correlation between the severity of pain and the Alvarado score. The pain management of acute abdomen in the ED was still suboptimal as evidenced by the existence of oligoanalgesia in this study.

References

1. Fitz RH. Perforating inflammation of the vermiform appendix; with special reference to its early diagnosis and treatment. Am J Medical Sciences 1886; 92: 321-346.

2. Hashemy AM, Saleem MI. Appraisal of the modified Alvarado Score for acute appendicitis in adults. Saudi Medical J. 2004; 25(9): 1229-1231.

3. Mahato IP, Karn NK, Lewis OD, Agrawal CS, Bhandari R. Effect of the Alvarado score on the diagnostic accuracy of right ileac fossa pain in an emergency. Trop Doct 2011; 41(1): 11-14

4. Chan MY, Tan C, Chiu MT, Ng YY. Alvarado score: an admission criterion in patients with right iliac fossa pain. Surg J R Coll Surg Edinb Ireland 2003; 2: 39-41.

5. Denizbasi A, Unluer EE. The role of the emergency medicine resident using the Alvarado score in the diagnosis of acute appendicitis compared with the general surgery resident. European J Emergency Medicine 2003; 10(4): 296-301.

6. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emergency Medicine 1986; 15: 557-564.

7. Fitzgerald DJ, Pancioli AM. Acute appendicitis. In: Emergency Medicine a comprehensive study guide. Tintinalli JE (Ed.). New York: McGraw-Hill, 2004, pp 520-523.

8. Ohmann C, Yang Q, Franke C. Diagnostic scores for acute appendicitis. Abdominal Pain Study Group. European J Surgery 1995; 161(4): 273-281.

9. Malik AA, Wani NA. Continuing diagnostic challenge of acute appendicitis: evaluation through modified Alvarado score. Aust N Z J Surgery 1998; 68(7): 504-505.

10. Althoubaity FK. Suspected acute appendicitis in female patients. Trends in diagnosis in emergency department in a University Hospital in Western region of Saudi Arabia. Saudi Med J 2006; 27(11): 1667-1673.

11. Lamparelli MJ, Hoque HM, Pogson CJ, Ball AB. A prospective evaluation of the combined use of the modified Alvarado score with selective laparoscopy in adult females in the management of suspected appendicitis. Ann R Coll Surg England 2000; 82(3): 192-195.

12. Douglas CD, Macpherson NE, Davidson PM, Gani JS. Randomised controlled trial of ultrasonography in diagnosis of acute appendicitis, incorporating the Alvarado score. BMJ 2000; 321(7266): 919-922.

13. Zeilke A, Sitter H, Rampp T, Bohrer T, Rothmund M. Clinical decision-making, ultrasonography, and scores for evaluation of suspected acute appendicitis**.** World J Surgery 2001; 25(5): 578-584.

14. McDonald GP, Pendarvis DP, Wilmoth R, Daley BJ. Influence of preoperative computed tomography on patients undergoing appendectomy. Am Surgery 2001; 67(11): 1017-1021.

15. Pruekprasert P, Maipang T, Geater A, Apakupakul N, Ksuntigij P. Accuracy in diagnosis of acute appendicitis by comparing serum C-reactive protein measurements, Alvarado score and clinical impression of surgeons. J Med Assoc Thailand 2004; 87(3): 296-303.

16. Bhattacharjee PK, Chowdhury T, Roy D. Prospective evaluation of modified Alvarado

score for diagnosis of acute appendicitis**.** J Indian Med Assoc 2002; 100(5): 310-314.

17. Owen TD, Williams H, Stiff G, Jenkinson LR, Rees BI. Evaluation of the Alvarado score in acute appendicitis. J R Soc Medicine 1992; 85(2):87-88.

18. Kalan M, Talbot D, Cunliffe WJ, Rich AJ. Evaluation of the modified Alvarado score in the diagnosis of acute appendicitis: a prospective study. Ann Royal College Surgery England 1994; 76(6): 418-419.

19. Kiely N, Williams N. Evaluation of the modified Alvarado score in the diagnosis of acute appendicitis: a prospective study. Ann R College Surgery England 1995; 77(2): 157.

20. Hsiao KH, Lin LH, Chen DF. Application of the MANTRELS scoring system in the diagnosis of acute appendicitis in children. Acta Paediatr Taiwan 2005; 46(3): 128-131.

21. Jo YH, Kim K, Rhee JE et al. The accuracy of emergency medicine and surgical residence in the diagnosis of acute appendicitis. Am J Emerg Med. 2010; 28(7): 766-70.

22. Collucciello SA, Lukens TW, Morgan DL. Assessing abdominal pain in adults: A rational, cost-effective, and evidence-based strategy. Emergency Medicine Practice 1999; 1(1): 1-20.

23. McKay R, Shepherd J. The use of clinical scoring system by Alvarado in the decision to perform computed tomography for acute appendicitis in the ED. Am J Emerg Med. 2007; 25(5): 489-93.

24. LoVecchio F, Oster N, Sturmann K. The use of analgesics in patients with acute abdominal pain. J Emergency Medicine 1997; 15(6): 775-779.