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# ASSOCIATION OF ALVARADO SCORE AND THE SEVERITY OF ACUTE APPENDICITIS

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## ABSTRACT

**Objective:** To determine the association between Alvarado score and the severity of acute appendicitis in an East Coast Hospital, Malaysia. **Methods:** The cross-sectional study involved reviewing the record of all 177 Patients operated for suspected acute appendicitis in the hospital. Data were collected using a proforma. The severity of appendicitis was divided into perforated or non-perforated from the histo-pathological examination reports. Alvarado score recorded during the presentation to hospital was recorded. Simple and multiple logistic regression analysis were used to determine the association between Alvarado score and the severity of acute appendicitis. **Results:** Prevalence of perforated appendicitis was 25.1%. The mean of Alvarado score was 7.5 (SD: 1.35). Multiple logistic regression analysis showed a significant association between Alvarado score and severity of acute appendicitis after adjusting for age, gender and duration of pain before presentation. **Conclusion:** Higher Alvarado score is associated with higher odds of perforation. Therefore, Alvarado score could be used not just for diagnostic purpose, but also for predicting the severity of appendicitis.

***Keywords: Appendicitis, Alvarado score, Perforation, Surgical Emergencies***

## INTRODUCTION

Appendicitis is the most common abdominal emergency with appendicectomies the most common emergency surgery (Humes & Simpson, 2006). It is most common between the ages of 10 to 20 years but could occur at any age (Addiss, *et al.*, 1990). The chances of undergoing appendectomy during a lifetime are about 20% in females and 12% in males (Addiss, *et al.*, 1990). The spectrum of appendicitis can range from early appendicitis to appendiceal perforation and abscess (Willemsen, *et al.*, 2002). The mortality and morbidity are influenced by the stages of the disease. In the case of perforation, the mortality is 5.1 per 1000 (Blomqvist, P.G., *et al.*, 2001). Urgent appendicectomy is a relatively safe procedure and the accepted treatment to prevent perforation with mortality rate of less than 1% (Humes & Simpson, 2006).

The primary presenting complaint of patients with acute appendicitis is abdominal pain. Despite the increased use of ultrasonography and computed tomography, the diagnosis of acute appendicitis in countries such as Malaysia relies on the surgeon thorough history and examination. However, this could be difficult, as the classical diagnostic sequence of colicky central abdominal followed by vomiting and migration of the pain to right iliac fossa may only present in 50% of patients (Yamini, D., *et al.*, 1998).The benefit of modalities such as computed tomography screening and ultrasonography despite having been shown in clinical trials has not been utilised fully in general practice due to lack of widespread availability (Flum & Koepsell, 2002).

Over the years, various scoring systems have been developed to aid surgeons in the diagnosis of acute appendicitis. Alvarado score was introduced in 1986 and has been extensively used in the diagnosing of acute appendicitis (Alvarado, 1986). It is a scoring system based on symptoms, clinical examinations and laboratory findings (Alvarado, 1986 and Kalan, M., *et al.*, 1994) The score has 6 clinical items (abdominal pain which migrates to the right iliac fossa, ketones in the urine or anorexia, nausea or vomiting, rebound tenderness, right iliac fossa tenderness and fever of 37.3 $^{o}$C or more) and 2 laboratory measurements (leucocytosis> 10,000 per mm3 and Neutrophilia> 70%) (Chan, Teo, and Ng, 2001). Tenderness in right iliac fossa and leucocytosis are considered the two most important factor. Therefore, assigned two points while the six other factors are assigned one point each giving a possible total

score of ten points. A score of <5 considered less likely to be appendicitis, a score of >5 were more likely (Douglas *et al.*, 2000). An Alvarado score of 7 or more increased the probability of acute appendicitis with a likelihood ratio of 3.1 (Ebell and Shinholser, 2014). Although Alvarado score is used for diagnosis of appendicitis, currently there is no study done on the association of Alvarado score and the perforation of appendicitis. The objectives of this study were (Humes & Simpson, 2006) to determine the prevalence of perforated appendicitis and (Addiss, *et al.*,1990) the association between Alvarado score and perforation of appendicitis among patients undergoing appendicectomy in an East Coast hospital, Malaysia.

## METHODOLOGY

**Data Collection:** We conducted a cross-sectional study in a hospital in East Coast of Malaysia between September 2016 to October 2017. We identified and traced the medical record of all patients that underwent appendicectomy between January 2013 and September 2014. Designated proforma was used to record information from the medical records. Information collected from the medical record were age, gender, duration of pain in days prior to presentation, Alvarado score on presentation, the time between diagnosis and operation and duration of the operation. We then traced the histopathological examination findings of the appendix samples send intraoperatively. Any medical record with more than 30% missing, incomplete required data or histopathological examination (HPE) result was not available were excluded from the study. **Data Analysis:** Data analysis was carried out using SPSS version 24.0. Prevalence of perforated appendicitis and 95% confidence interval was calculated. Perforated appendicitis was coded with binary coding '1' and non-perforated appendicitis was coded '0'. Non-perforated appendicitis included HPE reported as white appendix. Diagnosis other than white appendix and appendicitis were excluded from the analysis. The association between Alvarado score with the severity of appendicitis was done using simple logistic regression analysis followed by multiple logistic regression analysis adjusting for age, sex and duration of pain before presentation. We then rerun another multiple logistic regression analysis by dividing the subjects into two groups, Alvarado score $\geq 7$ and $\leq 6$, to determine the association of between-subject that scored for a high probability of appendicitis and the severity of appendicitis adjusting for age, sex and duration of pain before presentation. Ethics: Ethical approval was obtained from National Medical Research Register. The main ethical issue in this study involved confidentiality of the secondary data. The confidentiality of the subjects was maintained throughout the process of data collection, analysis and interpretation. No identifiable information was collected and data presented as collective and not by individual information.

## RESULTS

From the medical record, a total of 228 patients underwent appendicectomy in the hospital between January 2013 and September 2014. After excluding incomplete and missing data, 177 patients were included in the study. Figure 1 shows the flow diagram of the search strategy.

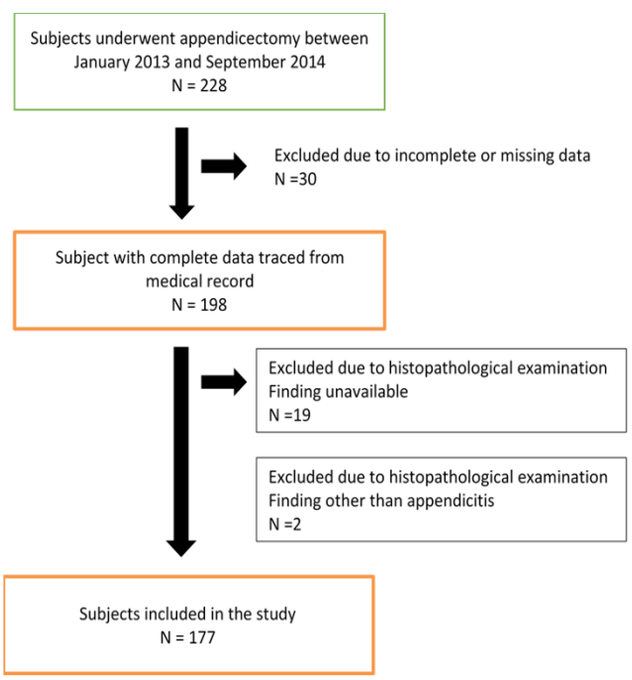


***Figure 1: Subject recruitment flowchart***

Table 1 shows the characteristics of the patients. Mean age of the patients were 22.0 (SD: 9.20) years old. The mean Alvarado score was 7.3 (SD: 1.67). About 75% of the subject had non-perforated appendicitis on HPE result (white appendix = 5 subjects and acute appendicitis = 127 subjects). HPE result with perforated appendicitis was reported for 45 subjects and 2 subjects HPE result reported other diagnoses (ovarian cyst and reactive lymphoid hyperplasia).

***Table 1: Characteristics of the subjects underwent appendicectomy in the hospital between January 2013 and September 2014 (n= 177)***

| Variable | Mean (SD) | Frequency (%) |
|---|---|---|
| Age (years) | 22.0 (9.20) | |
| Gender<br>Male<br>Female | | <br>83 (46.9)<br>94 (53.1) |
| Ethnicity<br>Malay<br>Other(s) | | <br>173(97.7)<br>4 (2.3) |
| Duration of pain before presentation (days) | 2.1 (1.00)[a] | |
| Alvarado score | 7.3 (1.67) | |
| Type of appendicitis<br>Non-perforated<br>Perforated | | <br>132 (74.6)<br>45 (25.4) |
| Time between diagnosis and operation (hours) | 9.0 (10.00)[a] | |
| Duration of operation (minutes) | 70.0 (25.77) | |

[a]*Median (interquartile range)*

Table 2 shows the frequency of the Alvarado score among the subjects. All the subjects had an Alvarado score of 5 and above. Majority of the patient scored 7 and above (79.6%) which indicated a high probability of acute appendicitis on the Alvarado Score.

***Table 2: Frequency distribution of the subjects according to Alvarado score (n=177)***

| Alvarado Score | Frequency (%) |
|---|---|
| 5 | 10 (5.7) |
| 6 | 26 (14.7) |
| 7 | 50 (28.2) |
| 8 | 47 (26.6) |
| 9 | 28 (15.8) |
| 10 | 16 (9.0) |

Table 3 shows the simple and multiple logistic regression analysis of Alvarado score and the severity of appendicitis. After adjusting for age, sex and duration of pain before presentation, Alvarado score was significantly associated with severity of appendicitis on HPE result.

***Table 3: Multiple logistic regression analysis of Alvarado score and the severity of acute appendicitis adjusting for age and gender (n = 177)***

| Variable | Crude OR (95% CI)[a] | *p*-value | Adjusted OR (95% CI)[a] | *p*-value |
|---|---|---|---|---|
| Alvarado score | 1.61 (1.22,2.13) | 0.001 | 1.69 (1.24, 2.30) | 0.001 |
| **Controlled variable** | | | | |
| Age | 0.99 (0.97, 1.02) | 0.676 | 0.99 (0.96, 1.03) | 0.650 |
| Gender<br>Male<br>Female | <br>0.66 (0.33,1.32)<br>1 | 0.237 | <br>0.60 (0.27, 1.32) | 0.206 |
| Duration of pain before presentation (days) | 1.06(0.89, 1.26) | 0.513 | 1.06 (0.87, 1.28) | 0.584 |

[a]*CI=Confidence interval*
*Constant -5.011*
*No multicollinearity and no interaction detected*
*Hosmer-Lemeshow test, p-value=0.850*
*Classification table 81.9% correctly classified*
*Area under the receiver operating characteristic was 86.4%*

Table 4 shows both the simple and multiple logistic regression analysis of Alvarado score ≥ 7 and the severity of appendicitis after adjusting for the three confounding factors. Alvarado score for subjects scoring ≥ 7 showed higher odds of having severe appendicitis compared to analysis using the entire study subjects. The model was fit with p-value for Hosmer-Lemeshow test was 0.820, classification table of 76.7% correctly classified cases and area under the receiver operating characteristic of 82.5%.

***Table 4: Multiple logistic regression analysis of Alvarado score ≥ 7 and the severity of acute appendicitis adjusting for age and gender (n = 177)***

| Variable | Crude OR (95% CI)[a] | *p*-value | Adjusted OR (95% CI)[a] | *p*-value |
|---|---|---|---|---|
| Alvarado score≥ 7 | 2.43 (1.08, 5.48) | 0.032 | 2.65 (1.02, 6.92) | 0.041 |
| **Controlled variable** | | | | |
| Age | 0.99 (0.97, 1.02) | 0.676 | 0.99 (0.96, 1.03) | 0.852 |
| Gender<br>Male<br>Female | <br>0.66 (0.33,1.32)<br>1 | 0.237 | <br>0.64 (0.30, 1.36) | 0.245 |
| Duration of pain before presentation (days) | 1.06 (0.89, 1.26) | 0.513 | 1.06 (0.87, 1.28) | 0.51 |

[a]*CI=Confidence interval*
*Constant -5.011*
*No multicollinearity and no interaction detected*
*Hosmer-Lemeshow test, p-value=0.820*
*Classification table 76.7% correctly classified*

## DISCUSSION

The mean age of patients undergoing appendicectomy in our study was 22 years old. The peak incidence of appendicitis has been reported occurring between the ages of 10 and 30 years (Gwynn, 2001). This is further supported by a study of acute appendicitis done in a university hospital in Kuala Lumpur, Malaysia that reported an average age of 27 years old among cases of appendicitis reported there (Lee, Jayalakshmi, & Noori, 1993). The cases of appendicectomy were slightly higher in female compared to male (53.1% vs 46.9%). This is on contrary to the commonly reported that the diagnosis of appendicitis is more common in men due to difficulty in diagnosis in female because of additional clinical considerations (Guss & Richards, 2000). However, our finding is in line with the previous study in the East Coast hospital which reported a higher rate of appendicectomy in female than male (Abdullah, 2015).

In view of the fact that the Malay race is the main ethnic group in Terengganu,about 98% of the workers were Malay. In Kelantan, Malays comprise about 94% of the population (DSM, 2017). The median time of presentation to healthcare was 2.1 days after onset of symptoms. This is supported by a study on acute appendicitis presentation in a hospital in South Africa which reported 63% of patients presented 2 days after the onset of their symptoms (17 Appendicitis are typically initially described as peri-umbilical colicky pain. This later intensifies, becoming more constant and sharper in nature and migrates to the right iliac fossa in the first 24 hours. This could explain the delay in presentation from the onset of pain (Nshuti, Kruger, & Luvhengo, 2014). The mean Alvarado score on presentation was 7.3 which is considered a high probability ofappendicitis.This is not surprising as our sample only consisted of subjects that underwent appendicectomy and did not include subjects that were sent back home or treated conservatively, who would probably have scored lower Alvarado score. This finding is congruent with subjects that underwent appendicectomy in a teaching hospital in Pakistan that reported mean Alvarado score of 8.4 (Nshuti, Kruger, & Luvhengo, 2014).

After adjusting for confounding factors such as age, gender and duration of pain before presentation, with every one unit increased in Alvarado score the odds of having perforated appendicitis was increased by 1.69 times. If we considered Alvarado score of $\geq 7$ against those scored lower than 7, the odds of having perforated appendicitis was higher at 2.65 times after adjusting or age, gender and duration of pain before presentation, This finding is supported by earlier study that reported Alvarado score above seven was associated with a higher risk of perforation as compared to at 7 or lower (Nshuti, Kruger, & Luvhengo, 2014). Therefore subjects that score Alvarado score $\geq 7$, which is considered as having high probabilities of acute appendicitis were also more likely to have more severe appendicitis as compared to those who scored lower. Therefore, despite Alvarado score has been commonly used as a tool for surgeons in diagnosing appendicitis, high score especially at or above 7 could also be interpreted as having higher odds or more severe appendicitis (Nshuti, Kruger, & Luvhengo, 2014).

Although these findings suggest there is a possible association between the Alvarado score and severity of appendicitis, a causal relationship and temporality could not be established due to the limitation of the study design. The preferred study design to evaluate the outcome is a cohort study. However, conducting a cohort study would have been more costly and time-consuming.As this study was conducted among subjects that underwent appendicectomy in a hospital, the findings should be interpreted as such and could not be generalised to subjects that did not undergo appendicectomy. The subjects in this study scored 5 or above in Alvarado score and must be interpreted as such. The result of the multiple logistic regression analysis as shown in Table 3 cannot be applied to subjects that scored less than 5 in Alvarado score. This study was conducted in a hospital in East Coast of Malaysia. Hence, the results cannot be generalised to subjects in other parts of Malaysia. Majority of the workers' population in this study were Malays (97.7%) which might be different in other states. We also used secondary data in this study. Therefore, there is no control over the type of data available and limited control over missing or incomplete data. However, secondary data eliminated interviewer bias that could have occurred in primary data collection.

## CONCLUSION

Alvarado score is still the most well-known scoring system to aid the diagnosis of acute appendicitis despite

advancement in imaging modalities and development of other scoring system. We have shown that for patients presenting and suspected of acute appendicitis in hospital and scored high on Alvarado score, they not only have higher odds of having appendicitis but the odds of having more severe appendicitis are also higher.

**Conflict of Interest**

The authors declare that they have no conflict of interest.

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