



Case Series

Sensitivity and specificity of the Alvarado Score for the timely differential diagnosis of acute appendicitis for a case series in Samoa

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ABSTRACT

Background: Timely diagnosis of acute appendicitis (AA) is essential for optimal management of abdominal pain emergency presentations. Improved diagnostic procedures should minimise progression to complicated appendicitis, as well as reduce the number of unwanted surgical interventions. The Alvarado Score is an important tool to assist with the management of AA based on clinically predictive values. The aim of the present study was to evaluate the sensitivity and specificity of the Alvarado Score as an instrument for the diagnosis of AA in our low-resourced context of Samoa.

Materials and methods: The lead investigator performed a retrospective clinical data review design of all patients admitted to the Tupua Tamasese Meaole Hospital Surgical Unit for AA from January 2015 to December 2016. Exclusion criteria were appendiceal abscess and/or mass, and final diagnosis 'not acute appendicitis'. Age, sex, village, Alvarado Score, Ultrasound Scan Result, surgical management, and histopathology result were the main variables entered into the SPSS statistical software package for analysis.

Results: Of the 225 patients (2–86 years) admitted for AA, 67.1% (N = 151) underwent appendicectomy, and the remaining 32.9% (N = 74) were treated with antibiotics. An Alvarado Score (≥ 5) showed 91.7% sensitivity and 50% specificity for AA. There was a significant relationship between the Alvarado Score and the Ultrasound Scan for AA ($p < 0.05$). Histology results showed complicated AA in 68.6% (N = 94) of cases. The negative appendicectomy rate was 2.6%.

Conclusions: The Alvarado Score is an effective tool for the timely differential diagnosis of AA in our Samoan context. The high rate of complicated acute appendicitis warrants investigation to further improve the management of AA in the Pacific Island setting.

1. Introduction

Acute appendicitis (AA) is the most common emergency surgery presentation worldwide [1]. Differential diagnosis of AA may be difficult in the emergency department setting, and failure of accurate diagnosis of AA is the main reason for persistently high rates of AA morbidity and mortality [1–3]. Given the risk of life-threatening complications from advanced stages of AA, appendicectomy is generally the recommended first-line treatment for all AA presentations to emergency departments [1,2].

A review of the surgical literature indicates that AA case presentations and management decisions vary between High-Income and

Low-and Middle-Income countries. For high-resourced nations, appendicectomies are relatively easy to perform, and surgical benefits significantly outweigh the risks and potential complications. Although the rate is in decline, high-income settings generally report a high negative rate of AA for appendicectomies, up to and including 15% [4,5]. In contrast, low- and middle-income nations report low negative rates of AA for appendicectomies, most probably due to presentation for emergency clinical care at advanced stages of the disease. Given that uncomplicated AA may be successfully managed non-operatively [6,7], an effective method for assessing AA in the emergency department of low-resourced contexts should be explored to minimise the caseload of surgical interventions (i.e., optimise the negative rate of AA for

Abbreviations: AA, Acute Appendicitis; AS, Alvarado Score; NPV, Non Predictive Value; PPV, Positive Predictive Value; TTM, Tupua Tamasese Meaole; USS, Ultrasound Scan.

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appendicectomies). There is currently no literature on the management of AA in the Pacific Islands.

The Alvarado Score and Ultrasound Scan are established diagnostic tools that guide clinical decision-making regarding management of appendicitis in the emergency setting [8–13]. The Alvarado Score is a clinical scoring system based on the eight signs and symptoms of AA (Fig. 1), and appendicectomy is recommended for patients with an Alvarado Score of 7–10. An Ultrasound Scan is performed to investigate for any other abdominal pathologies or alternative diagnoses. For patients with an intermediate Alvarado Score of 5–6, an Ultrasound Scan increases the sensitivity and specificity of AA diagnosis to 93.3% and 100%, respectively.

Samoa is a Polynesian nation of the Pacific islands (Fig. 2). There are geographical challenges, inexperienced health care workers, and financial constraints which cause delays in presentation to the main tertiary facility for definitive treatment. The Alvarado Score procedure was introduced to the Emergency Department of the national Tupua Tamasese Meaole (TTM) Hospital in 2013 with the aim of improving the efficiency of AA case management. Samoa has one Ultrasound Scan machine only, and the Alvarado Score should enable timely triage of suspected AA cases who may require emergency appendicectomy. The aim of the present study was therefore to evaluate the sensitivity and specificity of the Alvarado Score for the differential diagnosis of AA in our hospital setting in Samoa. A secondary aim was to calculate the negative rate of AA for appendicectomies in order to ascertain that it falls within acceptable clinical limits. The results of the study should guide the development of evidence-based guidelines for the management of appendicitis in Samoa and improve patient outcomes with timely referrals from the district hospitals.

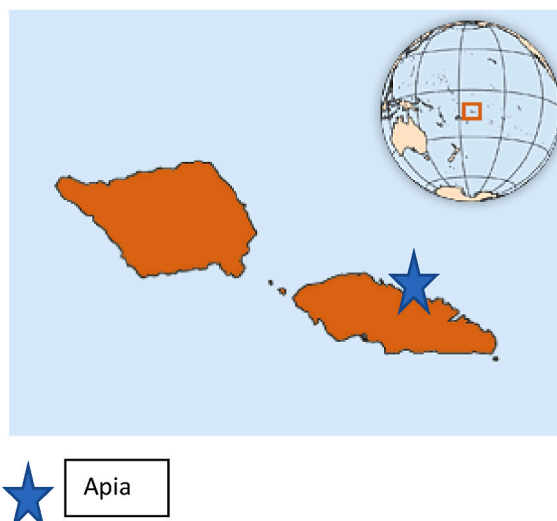


Fig. 2. Map of Samoa.

2. Methods

2.1. Registration

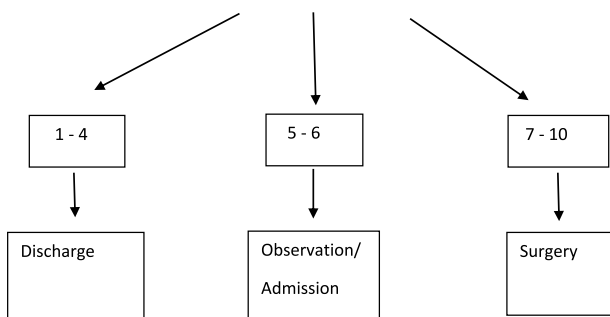
In accordance with the Declaration of Helsinki that "Every research study involving human subjects must be registered in a publicly accessible database", the present study was registered with [ClinicalTrials.gov](https://www.clinicaltrials.gov) (Protocol ID: s994956; [ClinicalTrials.gov](https://www.clinicaltrials.gov) ID: NCT05168410).

2.2. Study design and data collection

The present study is reported in line with the PROCESS 2020 criteria [14]. A retrospective single-centre consecutive case series study design was used to evaluate all AA cases seen by the Surgical Department of TTM Hospital over the 24-month period between 1 January 2015 and 31 December 2016. The clinical medical records were obtained by the lead investigator – a senior surgeon - from the National Health Service PATIS System, using the search terms ‘appendicitis’, ‘acute appendicitis’, and ‘appendicectomy’. A total of 289 records were retrieved. Thirty four (34) records were excluded having met the exclusion criteria: (1) final diagnosis was not AA (i.e., ectopic pregnancy, tubal ovarian abscess, other gynaecological pathologies, diverticulitis, Merkel diverticulitis, perforated ulcer), and (2) appendiceal abscess and/or appendiceal mass. There were thirty (30) clinical records with missing data, and these were also excluded from the study. The final number of records included for analysis was 225 cases. All 225 cases were initially treated with intravenous antibiotics upon presentation to the emergency department as per the National Health Service antibiotic guidelines: intravenous ceftriaxone and metronidazole was the first line of treatment, and alternative antibiotics were administered if unavailable (i.e., clindamycin + gentamycin or ampicillin, or gentamycin + metronidazole).

A purpose-designed data collection form and excel spreadsheet were created for the study. The following de-identified information was extracted from the clinical records: patient gender (male/female), age (years), address (urban/rural), time of admission (Morning/Afternoon/Night Shift), use of traditional/alternative medicine prior to attending emergency department (yes/no), administration of antibiotics by emergency department staff (yes/no), Alvarado Score (1-10), Ultrasound Scan for AA (Positive/Negative/Inconclusive/Not performed), management of AA (appendicectomy/antibiotic therapy), intra-operative macroscopic examination (Grade 1–5), histopathology result for AA (Positive/Negative/Inconclusive/Not available), length of stay in hospital (days), and mortality (yes/no).

ALVARADO SCORE	
Feature	Score
Migration of pain	1
Anorexia	1
Nausea	1
Tenderness in right lower quadrant	2
Rebound pain	1
Elevated temperature	1
Leucocytosis	2
Shift of white blood cell count to the left	1
Total	10



Predicted number of patients with appendicitis:

- Alvarado score 1-4 – 30%
- Alvarado score 5-6 – 66%
- Alvarado score 7-10 - 93%

Fig. 1. Alvarado score card.

2.3. Data analysis

The data was analysed using the SPSS (Version 2.1) statistical software package. Descriptive analysis was performed, and the chi-square test of significance was used to investigate for statistically significant differences between variables (significant at $p < 0.05$). The sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) were calculated for the Alvarado Score in identifying AA as confirmed by histopathology.

3. Results

The study cohort ($N = 225$) consisted of 147 males (65.3%) and 78 females (34.7%). There were 111 cases (49.3%) residing in urban areas, and 114 cases (50.7%) residing in rural areas. The age of cases ranged from 2 to 86 years with a mean of 27.6 years. 49.3% of cases were among children, adolescents, and young adults. Traditional or alternative medicine was reportedly sought by 9.3% (21) of participants. The mean age of cases undergoing surgery ($N = 151$ appendicectomies) was 27.3 years, and the mean age of cases treated conservatively ($N = 74$ antibiotic therapy and observation) was 28 years. There were no recorded cases of mortality from AA during the study period.

The Alvarado Score was recorded for all cases upon admission to the hospital by the emergency department. The most common Alvarado Score indicators were tenderness of the right iliac fossa ($N = 220$, 97.8%) and leucocytosis ($N = 164$, 72.9%) (Table 1). A significant relationship was calculated between the Alvarado Score and the Ultrasound Scan result ($p < 0.05$), indicating that the higher the Alvarado Score, the more likely the Ultrasound Scan will return a positive diagnosis of AA.

Appendicectomy was performed for 67.1% ($N = 151$) of the total study population (Males $N = 104$, 68.9%; Females $N = 42$, 31.1%). An open operation was performed for 83.4% ($N = 126$) of cases, followed by laparotomy (11.9% $N = 18$) and laparoscopy (4.6% $N = 7$). Post-operative complications were documented for 19 (12.6%) cases, and included wound infection, urinary tract infection, and pelvic abscess collection. Intra-operative, macroscopic findings were described in accordance with the Disease Severity Score for Appendicitis [15]: normal appendix ($N = 2$, 1.3%), Grade 1 Inflamed Appendix ($N = 65$, 43%), Grade 2 Gangrenous Appendix ($N = 21$, 13.9%), Grade 3 Perforated Appendix with localized free fluid ($N = 42$, 27.8%), Grade 4 Perforated Appendix with regional abscess ($N = 18$, 11.9%), and Grade 5 Perforated Appendix with diffuse peritonitis ($N = 3$, 2%).

Histopathology results were available for 94% ($n = 141$) of appendicectomies. The results were described as simple appendicitis or complicated appendicitis (i.e., perforated appendix). There were 90.7% ($N = 137$) of cases with positive histology for appendicitis, with 31.4% ($N = 43$) reported as simple appendicitis, and 68.6% ($N = 94$) reported as complicated appendicitis. Histopathology results were negative for appendicitis for 2.6% ($N = 4$) of cases. Laboratory results were unavailable for 6.6% ($N = 10$) cases.

A significant relationship was measured between Alvarado Score and Appendicectomy ($p = 0.000$), Alvarado Score and Histology Result ($p = 0.036$), and Ultrasound Scan and Appendicectomy ($p = 0.007$). There

Table 1
Frequency of signs and symptoms used for calculation of the Alvarado Score.

Feature	N = 225	%
Tenderness in right lower quadrant	220	98.8
Leucocytosis	164	72.9
Rebound pain	128	56.9
Nausea	124	55.1
Shift of WBC count to the left	123	54.7
Anorexia	119	52.9
Elevated temperature	117	52
Migration of pain	95	42.2

was no significant relationship between the ultrasound scan and histology result ($p = 0.162$).

The sensitivity, specificity, PPV, and NPV of the Alvarado Score was calculated based on the number of confirmed cases of AA by histopathology (Table 2). These values were calculated for Alvarado scores of ≥ 5 and ≥ 7 .

4. Discussion

The above findings demonstrated that the Alvarado Score is an effective tool for the timely diagnosis of AA in the Samoan emergency hospital setting. Implementation of the Alvarado Score instrument should (1) improve the triage of patients presenting to the Emergency Department or district hospitals, (2) facilitate priority referrals for an Ultrasound Scan (Alvarado Score ≥ 5), (3) enable timely differential diagnosis of AA and/or alternate abdominal pathologies, and (4) facilitate timely decision-making for cases requiring emergency surgery.

Histology results found that the negative appendicitis rate was low in the present study (2.6%). This is significantly lower than that reported in the literature, where negative appendicitis rates of up to 15% may be considered acceptable [5]. In our low-resourced context, it is especially desirable to maintain negative rates for any surgery as low as possible given the demand for other surgical emergency procedures, theatre time and resources. It was noted from the study that the majority of presentations to hospital had presented on Day 3 and Day 4 of symptoms which may explain the low negative surgical rates of appendicitis and the high rates of complicated appendicitis.

4.1. Limitations of the study

This is a retrospective review of clinical records, and thus biased towards people who are motivated and able to attend the emergency department of the national hospital for their healthcare.

The present study was conducted by the lead investigator towards the completion of a Masters thesis. There were inherent time and resource restrictions, such as data collection, entry and analysis being performed by the lead investigator alone. Future studies may be prospective in design, include a larger team of investigators for the quality control of data handling, and a strengthened statistical power with a larger study sample size.

5. Conclusion

The Alvarado Score is an effective tool for the timely diagnosis of AA in the emergency department of the national hospital in Samoa. We recommend an Alvarado Score of ≥ 5 for a PRIORITY Ultrasound Scan, and an Alvarado Score of ≥ 7 for surgical intervention for males and urgent USS for females to exclude gynaecological causes for their symptoms. This should enable timely decision-making for surgical management of acute appendicitis in Samoa.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Funding for your research

None.

Table 2
Alvarado score sensitivity and specificity.

	Sensitivity	Specificity	PPV	NPV
Alvarado Score (≥ 7)	63.5%	75%	98.86%	5.66%
Alvarado Score (≥ 5)	91.97%	50%	98.44%	15.38%

Ethical approval

Ethical approval was obtained from (1) Government of Samoa Ministry of Health - Health Research Ethics Committee, and (2) Fiji National University Health Research Ethical Committee. Gatekeeper approval was obtained from the Director of the TTM Hospital.

Consent

N/A. Retrospective review of de-identified clinical records.

Author contribution

The work was undertaken by SP as part of his Masters studies, and DH was his supervisor. Colleague AK assisted with the revision of the Masters thesis into the present format for journal publication.

Registration of Research Studies

N/A: Retrospective review of clinical records.

Name of the registry:

Unique Identifying number or registration ID:

Hyperlink to your specific registration (must be publicly accessible and will be checked):

Guarantor

Sione Pifeleti. The work was his research undertaken as part of a Masters degree.

Declaration of competing interest

No conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2021.103219>.

[org/10.1016/j.amsu.2021.103219](https://doi.org/10.1016/j.amsu.2021.103219).

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