



ST. PAUL'S HOSPITAL MILLENNIUM MEDICAL COLLEGE

**EVALUATION OF THE DIAGNOSTIC ACCURACY OF
ALVARADO SCORE AS COMPARED TO ABDOMINAL
ULTRASONOGRAPHY: A ONE YEAR REVIEW OF ACUTE
APPENDICITIS PATIENTS OPERATED AT ST. PAUL'S
HOSPITAL MILLENNIUM MEDICAL COLLEGE**

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**CLINICAL ADVISOR: DR. GELAN G/MICHAEL (MD, ASSISTANT
PROFESSOR OF SURGERY)**

**A RESEARCH PROPOSAL SUBMITTED TO THE DEPARTMENT OF
PUBLIC HEALTH, ST. PAUL'S HOSPITAL MILLENNIUM MEDICAL
COLLEGE IN PARTIAL FULLFILLMENT OF THE REQUIRMENT FOR
THE DEGREE OF DOCTOR OF MEDICINE**

MARCH, 2018

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Summary

Background

The decision to operate patients with diagnostic impression of appendicitis still poses a challenge worldwide notwithstanding the advances in modern radiographic imaging and diagnostic laboratory investigation. Differences in diagnostic accuracy have been observed by using clinical scores and imaging for appendicitis among various populations and clinical settings. [13,14,17]

Objectives

The objective of this study is to evaluate the diagnostic accuracy of Alvarado score as compared to abdominal ultrasonography in acute appendicitis patients operated in SPHMMC in the year 2017.

Methods

A hospital based analytic retrospective study will be carried out on a study population of 461 acute appendicitis patients operated in 2017 at SPHMMC. Simple random sampling technique will be used to select 210 of them for fair representation. A pretested checklist consisting of sociodemographic profile, Alvarado score parameters, abdominal ultrasonography and intraoperative findings will be used to collect the required data from medical charts. These will be entered into a computer and analyzed using SPSS statistical software. Chi-square tests and multivariable logistic regression with 95% CI at $P \leq 0.05$ and the area under the curve will be used to determine the diagnostic accuracies. The research is to be completed in the time frame from February to July 2018 with total cost of the project estimated as 4,439.60 Birr.

Result

From the total number of 210 patients that will be studied in the research, the pattern of appendicitis will be determined by age and sex with the type of operation undertaken. The intraoperative finding consistent with appendicitis and its complications will be identified. This

shall be used to determine retrospectively the sensitivity, specificity, positive and negative predictive value of Alvarado score and abdominal ultrasonography in reaching the accurate diagnosis of appendicitis.

Conclusion

The research will determine the accuracy of Alvarado score and abdominal ultrasonography for the better selection of a diagnostic approach with maximal sensitivity in time and cost efficient manner in acute appendicitis patients. And subsequently reduces negative appendectomy and complication rates.

Key words: Appendicitis, Alvarado score, Abdominal ultrasonography, SPHMMC.

List of Abbreviations and Acronyms

AA	Addis Ababa
CI	Confidence Interval
CT	Computed Tomography
MAS	Modified Alvarado Score
MRN	Medical Record Number
MSCT	Multi Slice Computed Tomography
SPHMMC	St. Paul's Hospital Millennium Medical College
SPSS	Statistical package for Social Science

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1. Introduction

1.1 Background

Abdominal pain is one of the most frequent reasons for visits to health care institutes. Although most patients will be found to suffer from self-limited conditions of little consequence, a subset of patients with acute abdominal pain will harbor serious pathology that requires major surgical or medical intervention. Early diagnosis, and particularly the early distinction of conditions that require urgent operation from those best managed non-surgically, must be the paramount principle that outweighs all other concerns [1].

Acute appendicitis, which is an inflammation of the inner lining of the vermiform appendix that spreads to its other parts, is said to be the most common cause of abdominal pain and surgical emergency requiring admission. Despite diagnostic and therapeutic advancement in contemporary medicine, appendicitis remains a clinical emergency [2]. Appendicitis may occur for several reasons like infection of the appendix but the most important being obstruction of the appendiceal lumen. If left untreated it has the potential for severe complications, including perforation and sepsis eventually leading to death [3].

The lifetime prevalence of appendicitis is approximately 1 in 7 worldwide [4]. The incidence of appendicitis seems to have risen greatly in the first half of 20th century, particularly in Europe, America and Australasia, with up to 16% of the population undergoing appendectomy. In the past few decades, the incidence has fallen dramatically in these countries, such that the individual lifetime risk of appendectomy is 8.6% and 6.7% among males and females respectively. In developing countries that are adopting a more refined western-type diet, the

incidence continues to rise. Acute appendicitis is relatively rare in infants, and becomes increasingly common in childhood and early adult life, reaching a peak incidence in the teens and early 20s. After middle age, the risk of developing appendicitis is quite small [5].

Right lower quadrant pain, gastrointestinal symptoms starting after the onset of pain, and a systemic inflammatory response with leukocytosis and neutrophilia, increased C-reactive protein concentration, and fever are considered key features for the diagnosis of appendicitis. However, no single sign, symptom or diagnostic test accurately confirms the diagnosis of acute appendicitis [6]. And since the picture of acute appendicitis may not be classical, a policy of early intervention to avoid perforation may lead to high negative appendectomy rates [7]. Difficulties in diagnosis arise in very young, elderly patients and females of reproductive age because they are more likely to have an atypical presentation, and many other conditions may mimic acute appendicitis in these patients [8].

In 1886, Reginald H. Fitz presented his findings regarding appendicitis and recommended consideration for operative treatment. In 1889, Charles McBurney described the indications for early laparotomy for the treatment of appendicitis [9]. During the following decade, the role of surgical treatment was discussed intensely between proponents of early appendectomy and of a more expectant management. It was recognized that most instances of appendicitis could resolve without surgical treatment. But, the problem was how to identify early the patients who had the progressive, often lethal form of the disease [10]. Eventually, early appendectomy became the accepted standard of care, with broad indications in order to prevent perforation. This resulted in an enormous increase in the number of appendectomies during the first decades of the 20th century. However, this had almost no impact on the incidence of perforated appendicitis or on the mortality of appendicitis [11]. In the 1970s, the negative effects of the large number of appendectomies of uninflamed appendices were noted, and the focus gradually shifted toward a more conservative approach to exploration [12].

The clinical diagnosis of appendicitis is a subjective estimate of the probability of appendicitis based on multiple variables that individually are weak discriminators; however, used in conjunction, they possess a high predictive value. This process can be made more objective by the use of clinical scoring systems, which are based on variables with proven discriminating

power and assigned a proper weight. The Alvarado score is the most widespread scoring system. It is based on sophisticated statistical analysis of symptoms, signs and laboratory data in acute appendicitis. The scoring system as described by Alvarado in 1986, is based on three symptoms, three signs and two lab findings. It is considered that use of the scoring system to make the clinical diagnosis would allow uniformity as more than one physician is involved in making the decision [13].

Imaging studies also play an important role due to the low specificity of clinical manifestations; abdominal ultrasound and abdominal computed tomography (CT) are the most commonly used. Abdominal ultrasound was first used in 1986 by Puylaert, who reported 63 - 99% sensitivity and 71-100% specificity. However, one disadvantage is that it is operator-dependent [14,15]. Abdominal CT with intravenous contrast is considered the gold standard for diagnosing appendicitis and has high sensitivity (99%) and specificity (97%). Its main disadvantages are the high cost and limited availability. It also involves radiation exposure, and allergic reactions to the contrast medium are a possibility [16].

Alvarado score is simple to use and easy to apply. It can reduce negative appendectomy rate to 0-5% without increasing morbidity and mortality. Ultrasonography is the most economical investigation to aid a clinician in diagnosing acute appendicitis. The accuracy offered by sonography should keep negative laparotomy ratio at approximately 10% which is improvement over the rate achieved by instinct alone [17].

1.2 Statement of the problem

Notwithstanding advances in modern radiographic imaging and diagnostic laboratory investigations, the diagnosis of appendicitis remains essentially clinical, requiring a mixture of observation, clinical acumen and surgical science. In an age accustomed to early and accurate preoperative diagnosis, acute appendicitis remains an enigmatic challenge and a reminder of the art of surgical diagnosis [13, 14].

The surgeon's goals are to evaluate a relatively small population of patients referred for suspected appendicitis and to minimize the negative appendectomy rate without increasing the incidence of perforation. Physicians at the emergency department must evaluate the larger group

of patients who present with abdominal pain of all etiologies with the goal of approaching the diagnosis of appendicitis with maximal sensitivity in a time and cost efficient manner [17].

Ethiopia has a growing number of hospitals capable of providing surgical interventions for patients with acute appendicitis [18, 19, 20] by surgeons trained to do appendectomy, one of these being St. Paul's Hospital Millennium Medical College. In this setup where the senior surgeons work only as consultants, patients with suspected appendicitis are assessed primarily by interns and junior residents of surgery, internal medicine, pediatrics and emergency medicine. The increasingly over-burdened emergency department, limited source of radiographic investigations and few radiologists especially during duty times and the weekends makes the accurate diagnosis of acute appendicitis needing appendectomy quite a challenge [29].

While there are a variety of factors that contribute to perforation and other complications of appendicitis which could potentially lead to death, the main factor is the time delay to diagnosis. On the other hand, removing normal appendix is an economic burden on both patients and health resources especially in a developing economy like Ethiopia's [18, 19, 20, 21]. In light of this, data that compares the diagnostic accuracy of Alvarado score and abdominal ultrasonography in this setup's acute appendicitis patients is the best way forward.

1.3 Significance of the study

Even though there are some pocket studies across different regions of Ethiopia about patterns of acute appendicitis, there is no study comparing the diagnostic accuracy of Alvarado score and abdominal ultrasonography in patients operated for acute appendicitis [18, 19, 20]. In the view of the above context and recognizing the rareness of similar studies in the country the main aim of this study is to evaluate the Alvarado score as an indicator of acute appendicitis, validate its application in a specific population, and compare it with the abdominal ultrasonography finding.

The study will also try to determine if the combination of both scores can increase the sensitivity and specificity of the diagnosis of acute appendicitis and point out the rate of negative appendectomy. By doing so, it will suggest the best approach to acute appendicitis in resource limited area and reduce both complications related to delay in diagnosis as well as the negative appendectomy rate.

2. Literature Review

2.1 Pattern of Appendicitis in Ethiopia

A one-year retrospective study was conducted on adult patients admitted in Tikur Anbessa Specialized Hospital in Addis Ababa Ethiopia with acute abdomen. During the study period there were 587 adult surgical emergency operations of which 214 (36.4%) were laparotomies for acute abdomen. From a total of 276 patients who were admitted with a diagnosis of acute abdomen, 235 patients were included in this study. Acute appendicitis accounting for 52% of cases was the leading cause of acute abdomen followed by intestinal obstruction (26%) and perforated Peptic ulcer disease (9%). There were 36 deaths giving an overall mortality rate of 15.3%. A higher mortality rate was observed in patients who presented late. Thus concluding, acute abdomen deserving emergency laparotomy is quite common in Tikur Anbessa Specialized Hospital. [18].

In another descriptive retrospective study in Mekelle hospital in Northern Ethiopia between September 2008 to August 2010, 196 patients with acute appendicitis were admitted. Majority of patients with acute appendicitis were between 20 - 29 years of age, accounting for 76 (38.7%), predominantly males affected than females. The frequent clinical presentations of acute appendicitis were abdominal pain 196 (100.0%), vomiting 107 (54.6%) and anorexia 97 (49.5%). The duration of presentation ranged from 12 hours to 5 days (Mean- 3.5 days). This study depicted that acute appendicitis is the commonest emergency surgical condition affecting the young in the study area. Early presentation, early diagnosis and prompt treatment showed to attribute to lower rate of complications. Additional modern imaging is fundamental to support diagnostic accuracy to significantly reduce or avoid negative explorations [20].

A retrospective analysis was undertaken on 200 cases of acute appendicitis surgically managed at Yirgalem Hospital, in Southern Ethiopia from January 1997 to December 1999. The disease accounted for 27.9% of the operations for acute abdominal emergencies and for 1.1% of total hospital admissions. Right lower quadrant tenderness was the leading physical finding. The rate of simple and perforated appendicitis was 45.5% and 44%, respectively. Out of the 200 patients operated upon for acute appendicitis 8 (4%) died [19].

2.2 Comparison of Alvarado score and abdominal ultrasonography

2.2.1 Study in Ethiopia

A prospective study done in Tikur Anbessa Specialized Hospital from July 2002 up to November 2003 evaluated a total of 194 patients with graded compression ultrasound. The outcome of 147 patients was known, of which 58 were operated and 89 were clinically followed. The sensitivity of ultrasound in diagnosing appendicitis was found to be 87.9% with specificity of 86.5%. The positive and negative predictive values were 80.9% and 91.7% respectively. Thus concluding that ultrasound can be used as imaging modality of choice in investigating appendicitis [34].

2.2.2 Studies in Africa

A retrospective study conducted over a 5 year period from January 2008 to December 2012 on 1000 patients with proven appendicitis on black South Africans showed 40% had inflamed non perforated appendices while 60% had perforated appendices upon intraoperative finding. Alvarado score were 1-4 in 20.9%, 5-6 in 35.7% and 7-10 in 43.4% making the sensitivity of Alvarado score stand at 71%. The study concluded that prospective validation of the Alvarado score and possible modification is needed to increase its relevance in their setting [35].

A cross-sectional study was conducted in Tanzania involving all patients suspected to have acute appendicitis at Bugando Medical Centre over a six-month period between November 2008 and April 2009. A total number of 127 patients were studied. All patients in this study underwent appendectomy. The perforation rate was 9.4%. Histopathological examination confirmed appendicitis in 85 patients (66.9%) and the remaining 42 patients had normal appendix giving a

negative appendectomy rate of 33.1%. The accuracy of MAS was 92.9% (males 91.5% and females 87.6%). The study showed that use of MAS provides a high degree of diagnostic accuracy and can be employed at Bugando Medical Centre to improve the diagnostic accuracy of acute appendicitis and subsequently reduces negative appendectomy and complication rates [21].

2.2.3 Studies in other parts of the world

In a study conducted in Mexico, all cases of abdominal pain suggestive of appendicitis presented to the author's hospital between 2013 and 2015 were analyzed. 251 patients with abdominal pain in the right lower quadrant were taken. Appendicitis was confirmed in 211 (84%) patients. For these patients, the average Alvarado score was 7.95/10 (± 1.25) vs. 5.7/10 (± 1.11) for patients who did not have appendicitis ($p < 0.001$). In patients with confirmed appendicitis, the average ultrasonographic score was 2.48/6 (± 1.06) vs. 0.6/6 (± 0.92) for patients who did not have acute appendicitis ($p < 0.001$). The ultrasonographic score has a sensitivity of 90% and a specificity of 87% with only two parameters. The combination of the Alvarado and ultrasonographic scores decreased the percentage of negative appendectomies to 2.36%. Hence the study concluded, the sum of the Alvarado and ultrasonographic scores provides an efficient alternative for diagnosing abdominal pain suggestive of appendicitis and predicts which patients should undergo surgery with good certainty [22].

In Iran, Alvarado score evaluations were performed on 300 patients that were referred to or presented to the emergency room of the authors' hospital with acute abdominal pain. The Alvarado scoring system had poor sensitivity at 37%, and the specificity of this scoring system was high at 95%. The findings suggest that patients presenting with abdominal pain and Alvarado scores greater than 7 are more likely to have appendicitis making it a good rule-in test, but it does not adequately rule-out appendicitis [23].

A study in comparing clinical diagnosis (control group) with a diagnostic protocol incorporating Ultrasound and Alvarado score (intervention group) was conducted in surgical A ward Lady

Reading Hospital in Pakistan from February 2004 to March 2006. Total of 308 patients with suspected acute appendicitis were considered for the study. 158 patients were randomized to control group and 150 patients to intervention group. Sensitivity and specificity of ultrasound and Alvarado scoring system were 97.91% and 75%, respectively. Ultrasound and the Alvarado scoring system is a diagnostic tool that leads to an early diagnosis and rapid surgical treatment of acute appendicitis. However it does not prevent complications or reduce the length of hospital stay [24].

In a study conducted in Turkey between June 2003 and February 2006 with 143 patients, the patients were divided into 3 groups according to Alvarado scores: group 1 (n = 18; 13%; score: 1-4), group 2 (n = 70; 49%; score: 5-7), and group 3 (n = 55; 38%; score: 8-10). Abdominal MSCT results were compared to histopathological diagnoses. Patients were then divided into 2 other groups according to pain onset (MSCT performed within the first 12 h of pain onset and MSCT performed thereafter). The positive predictive value of MSCT did not significantly differ between the 3 Alvarado groups (92.8% in group 1, 95.1% in group 2, and 98.0% in group 3). Thus concluding, MSCT should be performed even in patients in whom the clinical suspicion of appendicitis is low. MSCT is effective in patients with early-stage appendicitis [25].

In another study in India 350 patients suspected of acute appendicitis were admitted, investigated and treated. They were evaluated using Modified Alvarado Scoring and all cases were subjected to ultrasonography. MAS >7 was seen in 158 patients in whom 151(95.60%) had histopathologically proved acute appendicitis and 7 (4.43%) patients were histopathologically negative. The sensitivity is 98.44% for MAS and 98.33% for ultrasonography and specificity is 94.4% for MAS and 90% for ultrasonography. In acute appendicitis, MAS is a good diagnostic indicator, and it is highly sensitive in diagnosis of appendicitis. Combined use of MAS and ultrasonography is very effective in diagnosis of appendicitis and it helps in reducing number of negative appendectomy [26].

A prospective, randomized study conducted in Hungary, patients presenting at the authors' outpatient department with suspected appendicitis during a 1-year period were assigned in weekly alternation to either group A or group B. The group A patients were treated on the basis

of their Alvarado score, and the group B patients underwent treatment based on clinical judgment. The study investigated 269 patients (131 in group A and 138 in group B). The number of negative appendectomies was 12 (9.16 %) in group A versus 5 (3.6 %) in group B ($p = 0.063$). The clinical judgment had better specificity and sensitivity than the Alvarado score. The study findings showed clinical judgment to be more reliable in the diagnosis of acute appendicitis than the Alvarado score, but the score is a useful diagnostic aid, especially for young colleagues [27].

3. Research question

What is the diagnostic accuracy of Alvarado score as compared to abdominal ultrasonography in acute appendicitis patients operated in SPHMMC in the year 2017?

4. Research Objectives

4.1 General objective

- To evaluate the diagnostic accuracy of Alvarado score as compared to abdominal ultrasonography in acute appendicitis patients operated in SPHMMC in the year 2017

4.2 Specific Objectives

- To analyze the patterns of operation decisions made by Alvarado score as compared to abdominal ultrasonography in acute appendicitis patients
- To determine the retrospective accuracy of judgment made by Alvarado score as compared to abdominal ultrasonography based on the intra operative finding
- To determine the negative appendectomy rate

5. Methods and Materials

5.1 Study setting

The study will be conducted in St. Paul's Hospital Millennium Medical College which is located in Addis Ababa the capital city of Ethiopia, with an estimate of 4.56 million metro Politian inhabitants [28]. The Hospital was built by the late Emperor Haile Selassie I in 1969 and the College was established through a decree of the council of ministers in 2010 although the medical school opened in 2007. Currently it has an inpatient capacity of 700 beds and serves an average of 1200 emergency and outpatient clients on daily basis. It has more than 2800 clinical, academic and administrative and support staffs that provide medical specialty services to patients who are referred from all over the country, teach medicine and nursing students and do basic and applied researches. It also gives 15 post graduate residency programs and 17 subspecialty or fellowship programs [29].

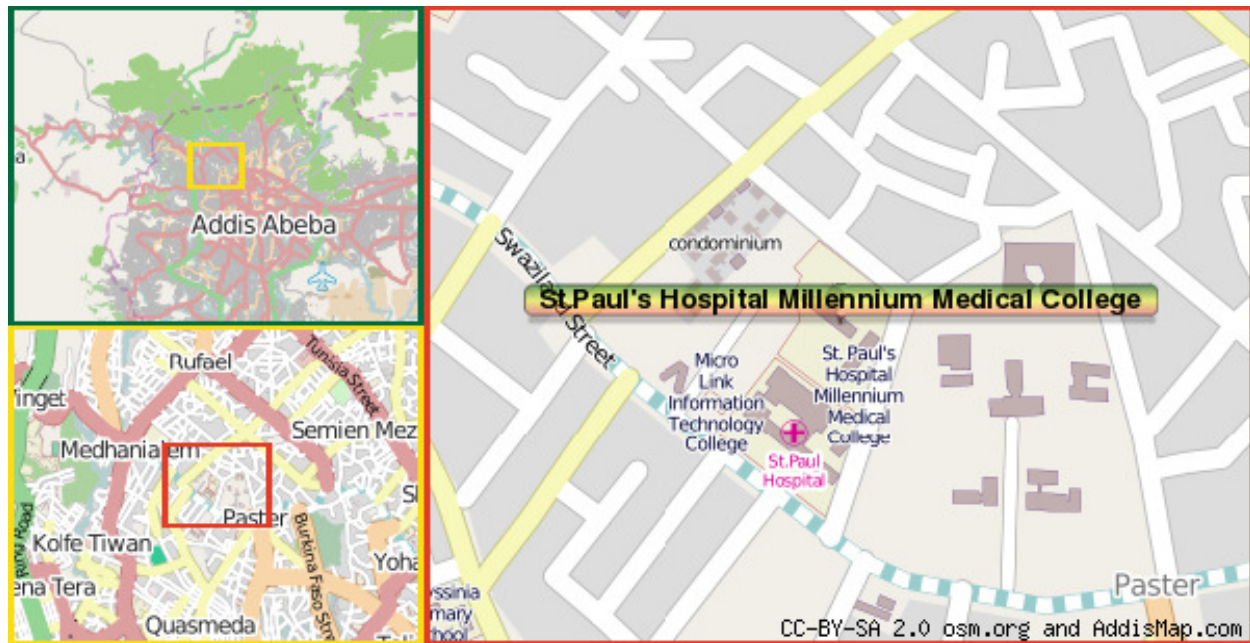


Fig. 1: Map of SPHMMC

5.2 Study design

A hospital based retrospective analytic study will be carried out for the attainment of the above mentioned study objectives and to meet the constraints of resource, manpower and time.

5.3 Source population

All medical records of patients who were operated in SPHMMC for acute appendicitis will be taken as the source population for this study.

5.4 Study population

All medical records of patients who were operated in the year 2017 in SPHMMC for acute appendicitis will serve as the study population.

5.4.1 Inclusion Criteria

- Patients who have undergone operation with the impression of acute appendicitis at SPHMMC in the year 2017 regardless of age and sex.

5.4.2 Exclusion criteria

- Patients whose medical record does not fulfill the parameters to do the Alvarado score
- Patients who don't have an abdominal ultrasonography result attached to their charts
- Patients whose operation note or intraoperative finding is missing from their charts

5.5 Sample size determination

The number of patients who underwent operation for appendicitis in the year 2017 at SPHMMC is 461. To calculate the sample size, by taking 'p' as the reasonable estimate of the key proportion to be studied and 'd' as the degree of accuracy required which is the allowed deviation from the true proportion in the population as a whole with a confidence level required (1-α), the following formula is used:

$$n = \frac{Z_{\alpha/2}^2 p(1-p)}{d^2}$$

The sample size of this study is determined from a previous study conducted in Tikur Anbessa Specialized Hospital on acute abdomen patients which determined the rate of admission for acute appendicitis as 52% retrospectively over one year period[18].

So by considering 52% as the expected proportion of acute appendicitis, any particular outcome to be within 5% marginal error and 95% CI of certainty. Using the adjusted formula for N<10,000, since the total study population is 461:

$$z = 1.96 \quad p = 0.52 \quad d = 0.05$$

$$n_0 = \frac{1.96^2(0.52 \times 0.48)}{0.05^2} = 383.55 \approx 384$$

$$n = \frac{\frac{Z^2 p(1-p)}{d^2}}{1 + \frac{1}{N} \left(\frac{Z^2 p(1-p)}{d^2} - 1 \right)}$$

$$n = \frac{384}{1 + 1/461(384-1)} = 209.83 \approx 210$$

So from a total of 461 patients operated for appendicitis, 210 of them will be taken for this study.

5.6 Sampling technique

The entire list of the 461 patients MRN operated for appendicitis in 2017 at SPHMMC will be obtained from the surgery logbook kept at the operation theatre. To have a fair representation of the population from both sexes and all age groups simple random sampling will be applied from the list of MRN to select the 210 patient medical charts.

5.7 Study variables

5.7.1 Independent variable

- Sociodemographic characteristics: sex, age
- Type of operation undertaken: Appendectomy or Laparotomy
- Intraoperative finding: complicated, uncomplicated, indeterminate
- Length of operation time
- Duration of patient's stay in the hospital

5.7.2 Dependent variables

- The Alvarado parameters and the total Alvarado score
- The Abdominal ultrasonography finding

5.8 Operational definition

Alvarado score: a scoring system used in the diagnosis of appendicitis which has 6 clinical items and 2 laboratory measurements and scored in the following manner:

Table 1: Alvarado score [30]

Parameters of Alvarado score	Score given
Migration of abdominal pain to right lower quadrant	1
Anorexia or loss of appetite	1
Nausea or vomiting	1

Tenderness in right iliac fossa	2
Rebound pain	1
Elevated temperature (37.3 °C)	1
Leucocyte count $\geq 10 \times 10^9 /L$	2
Differential white cell count with neutrophils > 75%	1
Total score	10

Out of a total score of 10, the Alvarado score interpretation is as follows:

- <3: Low likelihood of appendicitis
- 4-6: Consider further imaging
- ≥ 7 : High likelihood of appendicitis [30]

Abdominal ultrasonography result suggestive of appendicitis: is consistent with following

- Visualization of non-compressible appendix
- Appendicular diameter >6mm
- Diffuse hypoechogenicity of appendix
- Lumen distended with iso/hyperechoic material
- Visualization of appendicolith
- Peri-appendicular fluid collection
- Peri-appendicular fat collection [22, 24, 26]

Appendectomy: is an operation for early non-perforated appendicitis with an incision made in the right lower quadrant at McBurneys point (one-third of the distance from the anterior superior iliac spine to the umbilicus). The incision can be a McBurney (oblique) or Rocky-Davis (transverse) right lower quadrant muscle splitting type [31].

Laparotomy: is an operation type which involves a midline incision over the abdomen done to explore the abdominal cavity with its viscera in cases like perforated appendicitis [32].

Complicated appendicitis: refers to perforated appendicitis commonly associated with an abscess or phlegmon in the intraoperative finding [33].

5.9 Data collection procedures and data collection tools

The list of the charts of patients who have undergone surgery for acute appendicitis in SPHMMC during 2017 will be obtained from the log book of the operation theatre. The data that is needed for this research shall be collected by reviewing the charts using a checklist developed for this study.

5.10 Data quality management

The data collecting checklist used will be standardized for all the study variables and prepared in English. A pretest shall be done on 5% of the study population. The data collection will be conducted by the investigator of this research (a medical intern at SPHMMC) who will go thoroughly into the medical charts of patients to record all the available data needed for the research.

5.11 Data processing and analysis

Prior to data entry, it will be checked for errors and coded; next, data will be entered into the computer using SPSS software. Descriptive statistics will be carried out to describe the pattern of appendicitis in terms of age and sex. Binary and multivariable logistic regression analyses will be used to determine the presence of statistically significant associations between the measured diagnostic accuracy of Alvarado score and abdominal ultrasonography and the intraoperative finding. Crude and adjusted odds ratios with 95% CI will be calculated and a p value less than 0.05 will be considered statistically significant. Receiver operating characteristic and the area under the curve will be analyzed. Then, it will be interpreted and reported in the form of text document, charts and figures.

5.12 Ethical considerations

As charts contain vital information regarding patients demographic factors and health status, proper chart handling will be given priority. All charts taken from the chart store for the study shall be returned timely and properly as they may be needed for other purpose. The confidentiality of patients health record will be maintained through avoiding identifies like name on the check list. The proposal of this study will be reviewed by the Research review board to get clearance and letter of cooperation.

5.13 Dissemination of Findings

After being completed, the research paper will be submitted to SPHMMC's department of public health. The results and recommendations of the study will be given to Surgery, Internal medicine and Pediatrics departments of SPHMMC to be of use in their Emergency unit practice.

6. Budget required

Table 2: Budget required for the study of evaluation of the diagnostic accuracy of Alvarado score as compared to abdominal ultrasonography: a one year review of acute appendicitis patients operated at SPHMMC, AA, 2018

Items	Unit price in Birr	Quantity	Total
Material cost			
Printing	1.50 Br.	200 pages	300.00 Br.
Photocopy	1.00 Br.	400 pages	400.00 Br.
Pen	5.00 Br.	2	10.00 Br.
Pencil	4.00 Br.	4	16.00 Br.

Eraser	5.00 Br.	2	10.00 Br.
Personnel Cost			
Medical chart retrieval with the pretest included	5.00 Br.	230 charts	1,150.00 Br.
Data collection	5.00 Br.	230 charts	1,150.00 Br.
Miscellaneous (Communication, Internet, Transport)			1,000.00 Br.
Total			4,036.00 Br.
Total with 10% contingency			4,439.60 Br.

7. Work plan

Table 3: Work plan for the study of evaluation of the diagnostic accuracy of Alvarado score as compared to abdominal ultrasonography: a one year review of acute appendicitis patients operated at SPHMMC, AA, 2018

Activity	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Title selection									
Proposal development									

Proposal approval and ethical clearance									
Data collection									
Data analysis									
Final report writing									
Thesis defense and final report submission									

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Assurance of Investigator

The undersigned agrees to accept responsibility for the scientific , ethical and technical conduct of the research Project and for provision of required progress reports as per terms and conditions of the Research and Publication Directorate or /and Department of Public Health of St Paul's Hospital Millennium Medical College.

Name of Investigator: Dr. Hawi Furgassa

Date_____ Signature_____

Approval of Advisors

Advisors Name	Signature	Date
1. Mr. Samson Zegeye _____	_____	_____

2. Dr. Gelan G/Michael _____

Annex I: Research Checklist

St. Paul's Hospital Millennium medical college research checklist developed for reviewing medical charts to conduct the study on Evaluation of the diagnostic accuracy of Alvarado score as compared to abdominal ultrasonography in acute appendicitis patients operated in SPHMMC in the year 2017

MRN _____

Serial No. _____

A. Sociodemographic profile

1. Age in years _____

2. Sex ☐ Male ☐ Female

3. Region _____

4. Marital status ☐ Single ☐ Married ☐ Widowed
- ☐ Other ☐ Not documented
5. Religion ☐ Orthodox ☐ Muslim ☐ Protestant
- ☐ Catholic ☐ Other ☐ Not documented
6. Educational Status ☐ Illiterate ☐ Read and write ☐ Primary school (1-8)
- ☐ Secondary (9-12) ☐ Above secondary ☐ Not documented

B. Operation-related category

7. Mode of operation ☐ Appendectomy ☐ Laparotomy
8. Previous abdominal surgery ☐ Yes ☐ No
9. Operation time in minutes_____
10. Duration of hospital stay in days_____
11. Intra operative finding
- ☐ Appendicitis confirmed
- ☐ Appendicitis ruled out
- ☐ Other diagnosis_____
- ☐ Indeterminate finding
12. If appendicitis confirmed specify intraoperative finding with:
- ☐ Uncomplicated appendicitis

- ☐ Complicated appendicitis (perforated)

13. If complicated appendicitis specify with:

- ☐ Abscess
- ☐ Phlegmon
- ☐ Other_____

C. Alvarado score

Table 4: Parameters of Alvarado score checklist

Parameters of Alvarado score	Score given	
Migration of abdominal pain to right lower quadrant	☐ 0	☐ 1
Anorexia or loss of appetite	☐ 0	☐ 1
Nausea or vomiting	☐ 0	☐ 1
Tenderness in right iliac fossa	☐ 0	☐ 2
Rebound pain	☐ 0	☐ 1
Elevated temperature (37.3 °C)	☐ 0	☐ 1

Leucocyte count $\geq 10 \times 10^9 /L$	☐ 0	☐ 2
Differential white cell count with neutrophils > 75%	☐ 0	☐ 1
Total score		

Table 5: Total score of Alvarado checklist

Based on the total score of the Alvarado score:	<3: Low likelihood of appendicitis	☐
	4–6: Consider further imaging	☐
	≥ 7 : High likelihood of appendicitis	☐

D. Abdominal ultrasonography result

Table 6: Abdominal ultrasound features of appendicitis checklist

Positive abdominal ultrasound features for appendicitis	Yes if documented	No if not documented
Abdominal ultrasound result	☐	☐
Visualization of non-compressible appendix	☐	☐
Appendicular diameter >6mm	☐	☐
Diffuse hypoechogenicity of appendix	☐	☐
Lumen distended with iso/hyperechoic material	☐	☐

Visualization of appendicolith	☐	☐
Peri-appendicular fluid collection	☐	☐
Peri-appendicular fat collection	☐	☐

Table 7: Abdominal ultrasound features suggestive of appendicitis checklist

Number of positive abdominal ultrasound features of Appendicitis		
Suggestive of appendicitis (If number of positive abdominal ultrasound result ≥ 1 yes)	☐ Yes	☐ No

Abdominal ultrasound finding suggestive of other diagnosis_____

Annex II: Dummy tables for statistical analysis

Dummy tables developed for analyzing results for the study on Evaluation of the diagnostic accuracy of Alvarado score as compared to abdominal ultrasonography in acute appendicitis patients operated in SPHMMC in the year 2017 are presented below.

Table 8: Sociodemographic pattern of appendicitis

Sociodemographic profile		Appendicitis confirmed (number and percentage)	Negative appendectomy (number and percentage)	P- value
Total number of patients				
Sex	Male			
	Female			
Age Category	<10 years			
	10-20 years			
	21-30 years			
	31-40 years			

	>40 years			
Mean Age				

Table 9: Diagnostic parameters of appendicitis

Diagnostic Parameters		Appendicitis confirmed (number and percentage)	Appendicitis not confirmed (number and percentage)	P-value
Alvarado score category	<3			
	4–6			
	≥7			
Mean Alvarado score				
Positive Abdominal ultrasound finding				
Negative Abdominal ultrasound finding				

Table 10: Percent distribution of the Alvarado parameters

Parameters of Alvarado score	Percent distribution of the Alvarado parameters		
	Males	Females	Total
Migration of abdominal pain to right lower quadrant			
Anorexia or loss of appetite			
Nausea or vomiting			
Tenderness in right iliac fossa			
Rebound pain			
Elevated temperature (37.3 °C)			
Leucocyte count $\geq 10 \times 10^9 /L$			
Differential white cell count with neutrophils > 75%			

Table 11: Percent distribution of positive abdominal ultrasound finding

Positive abdominal ultrasound features for appendicitis	Percent distribution of positive abdominal ultrasound finding		
	Males	Females	Total
Abdominal ultrasound result			
Visualization of non-compressible appendix			
Appendicular diameter >6mm			
Diffuse hypoechogenicity of appendix			
Lumen distended with iso/hyperechoic material			
Visualization of appendicolith			
Peri-appendicular fluid collection			
Peri-appendicular fat collection			

Table 12: Diagnostic parameters of appendicitis sensitivity and specificity

Diagnostic parameters		Sensitivity	Specificity	Odds Ratio
Alvarado score category	<3			
	4–6			
	≥7			
Positive Abdominal ultrasound finding				

Table 13: Diagnostic parameters of appendicitis predictive value

Diagnostic Parameters		Positive predictive value	Negative predictive value	Diagnostic accuracy
Alvarado score category	<3			
	4–6			
	≥7			
Abdominal ultrasound				

finding			
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