INTRODUCTION

Acute appendicitis remains the most common cause of emergency abdominal surgery. Its incidence is 1.5-1.9 per 100,000 and is 1.4 times greater in men. The life time risk is 7%. It peaks in the second and third decades of life. Over 400,000 appendectomies are performed annually in Pakistan. It is one of the most common emergency surgical procedures performed by junior surgeons.

Patient history and clinical examination remain essential tools in the diagnosis of acute appendicitis but scoring systems, laboratory, radiographic and imaging tools are also vital. These include the ubiquitously available and easy to interpret baseline investigations. Imaging studies include ultrasonography and computerised tomography. Among the scoring systems, the Lintula score developed for the diagnosis of acute appendicitis can be used in children and adults and can be easily calculated.

Despite these tools, the rate of negative appendectomies is still high; between 15 - 30%. Classic teaching allows for a negative appendectomy rate of 5 - 15% keeping in mind the adverse effects of non-operability in a true appendix and advantages of safety in a negative exploration. Computed tomography reduces it from 24% to 7.6%, respectively.

In developing countries, routine imaging is not feasible due to cost, non-availability and the side-effects of contrast media and radiation exposure. Alternatively, scoring systems are economical, easy to perform and interpret. The Alvarado score is associated with a high rate of negative appendectomy in females, whereas the Lintula score has been shown to have a significantly higher specificity for acute appendicitis than the Alvarado or even clinical decision-making. It also highly corresponds to the histo-pathological results.

This study was, therefore, carried out to analyze the effectiveness of Lintula score in the diagnosis and reduction of negative appendectomies.

METHODOLOGY

This analytical study was carried out in the Surgical Unit of Khyber Teaching Hospital, Peshawar, Pakistan. Approval of the research and ethical committees was taken. Case files and charts of a total of 408 patients presenting to us in the emergency with a diagnosis of acute appendicitis from August 2012 to April 2014 were obtained. Written informed consent was taken in all cases. All these patients were cases diagnosed clinically as acute appendicitis and operated. Patients who had interval, elective or incidental appendectomy were excluded. Uniform guidelines of management were applied in all cases. The standard operating technique...
for appendectomy with a right lower quadrant incision and primary closure was followed. Case was considered as a negative appendectomy by per-operative absence of signs consistent with acute appendicitis, e.g. acute inflammation.

Sample size calculation showed that a minimal of 384 patients were required for 95% confidence level, 5% confidence interval and the estimated population of 500,000 patients served annually. Demographic data, Total Leukocyte (TLC) and neutrophil counts, Alvarado score, Lintula score, and per-operative confirmation of true acute appendicitis status was collected in all cases. The TLC and neutrophil counts were obtained at the Pathology Department of Khyber Teaching Hospital, Peshawar.

Data analysis was conducted with SPSS version 20 and MedCalc 12.5. Comparison of categorical data was done with Pearson chi-square and of interval data with t-test. Receiver operating characteristic curve and area under the curve was calculated for Lintula score. P-values were obtained for all these tests with statistical significance at < 0.05. Appropriate cut-off points were identified for optimum sensitivity, specificity and positive and negative predictive values were also obtained.

### RESULTS

Out of a total 408 patients, 72 (17.6%) were found to have a normal appendix per-operative; (negative appendectomy rate = 17.6%) whereas 336 (82.4%) cases had per-operative findings of acute appendicitis (true appendectomy rate = 82.4%). Statistical characteristics are given in Table I. Chi-square analysis of gender distribution between the groups was significant (p=0.009) with more male patients 45 (62.5%) in negative appendectomy group compared to 153 (45.5%) in the other group. Other statistically significant findings between the groups using t-test were higher values for the true appendectomy group regarding pre-operative symptom duration (hours) 29.1 ± 6.3 (p < 0.001), admission body temperature (°F) 99.88 ± 0.84 (p=0.009) and Lintula score 25.35 ± 3 (p < 0.001); t-test analysis of mean age (years) between the groups was statistically insignificant (p=0.311).

The ROC curve was calculated for various coordinate points as shown in Table II. The first half of Table II shows estimated specificity at fixed sensitivity and estimated sensitivity at fixed specificity, respectively. The highest specificity of 92.68% was obtained for a fixed sensitivity of 80% at the criterion ≤ 20.3 Lintula score.

### Table I: True and negative appendectomy group comparison.

<table>
<thead>
<tr>
<th></th>
<th>True appendectomy (TA)</th>
<th>Negative appendectomy (NA)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>336 (82.4%)</td>
<td>72 (17.6%)</td>
<td>0.009</td>
</tr>
<tr>
<td>Males : Females</td>
<td>153 (45.5%) : 183 (54.5%)</td>
<td>45 (62.5%) : 27 (37.5%)</td>
<td></td>
</tr>
<tr>
<td>Male female ratio</td>
<td>1: 1.196</td>
<td>1 : 0.6</td>
<td>-</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>22.94 ± 8.56</td>
<td>21.75 ± 10.9</td>
<td>0.311</td>
</tr>
<tr>
<td>Symptom duration (hours)</td>
<td>29.1 ± 6.3</td>
<td>26.3 ± 6.7</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Admission temperature (°F)</td>
<td>99.88 ± 0.84</td>
<td>99.65 ± 0.61</td>
<td>0.009</td>
</tr>
</tbody>
</table>

**Footnote:** a: True appendectomy, b: Negative appendectomy, c: degree Fahrenheit.

### Table II: ROC Curve analysis of the Lintula score.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Sensitivity at fixed specificity</th>
<th>Specificity at fixed specificity</th>
<th>Criterion</th>
<th>Sensitivity at fixed specificity</th>
<th>Specificity at fixed specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 20.3</td>
<td>80%</td>
<td>92.68%</td>
<td>≤ 22.4</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>≤ 20.6</td>
<td>90%</td>
<td>90.54%</td>
<td>≤ 20.7</td>
<td>90%</td>
<td>92.5%</td>
</tr>
<tr>
<td>≤ 20.8</td>
<td>95%</td>
<td>89.46%</td>
<td>≤ 18.9</td>
<td>95%</td>
<td>56.94%</td>
</tr>
<tr>
<td>≤ 20.9</td>
<td>97.5%</td>
<td>88.93%</td>
<td>≤ 18.4</td>
<td>97.5%</td>
<td>47.22%</td>
</tr>
</tbody>
</table>

**Footnote:** a: Receiver operator characteristic curve, b: Confidence Interval, c: Positive Likelihood Ratio, d: Negative Likelihood Ratio.
The highest sensitivity of 100% was obtained for a fixed specificity of 80% at the criterion ≤ 22.4 Lintula score. The optimal cut-off point from the criterion values and coordinates of the ROC-curve, as shown in the latter half of Table II, was ≤ 21 with 100% sensitivity and 88.4% specificity.

Table III shows the diagnostic measures and statistics for the Lintula score from the ROC curve. It shows that, at the criterion value of ≤ 21, the area under the curve was 0.963, with a standard error of 0.007, false positive rate of 0.116, positive likelihood ratio of 8.62, J-value of 0.88 and a p-value of < 0.0001, respectively.

**DISCUSSION**

Acute appendicitis is a diagnosis predominantly made on clinical grounds. Some cases can be managed conservatively but most eventually have to be operated such that the risk of appendectomy in emergency is 12% and 23% in men and women, respectively. Modern medicine and surgical techniques have reduced the overall risk but complications are still high for certain subgroups e.g. diabetics, immuno-compromised and extremes of age. These complications are associated with increased morbidity and cost of healthcare. The mortality associated with acute appendicitis has also been brought down to < 1% with modern surgical techniques. Despite such successes, healthcare facilities have to cope with a large amount of patient turn-over. Negative appendectomies are, therefore, associated with greater cost of healthcare, unnecessary admissions, morbidity and waste of resources. These can be prevented with reduction of negative appendectomies and this also increases the over-all efficiency. A helpful tool in this regard can be the Lintula score.

The Lintula score was developed by Hannu Lintula and colleagues in Turku, Finland in 2009. It is a user friendly system and can be easily applied. It was originally developed for use in the pediatric population. It is also used in the adult population with good precision and over-all accuracy. This study was conducted to apply and make use of the Lintula system as a tool for reduction of negative appendectomies.

Various studies have placed the sensitivity and specificity of the Lintula score as; 83.9% and 96.4%, 100% and 88%, 100% and 98%, and 87.2% respectively. In this study, these came out to be 100% and 88.4% respectively. Lintula et al. and Konan et al. showed that the criterion used for true appendicitis should be ≥ 21 and to rule one out completely, it should be ≤ 15. In this study, these criteria were found to be the same i.e. 21 as the optimum criterion for diagnosis as true appendicitis.

Analysis of the Lintula score by Lintula et al. and Konan et al. showed that it is associated with greater positive predictive value and specificity but a lower negative predictive value and sensitivity. The positive and negative predictive values of the Lintula score for the optimal cutoff point as determined by various researchers varied as 92.9% and 91.4% by Kirkil et al., 83% and 100% by Lintula et al., 98% and 86% by Lintula and Kokki et al. and 87.2% and 87.8% by Konan et al. respectively. In this analysis, the positive and negative predictive values were 97.3% and 100% respectively. This study was focused on using the Lintula for reducing negative appendectomies among patients with a diagnosis of acute appendicitis, which explains these higher values.

The overall accuracy of the Lintula score as reported in the above mentioned studies was; 91.9% by Kirkil et al., 92% by Lintula et al., 92% by Lintula and Kokki et al. and 87.5% Konan et al. respectively. In this study it was 90.4%. The area under the curve for a 95% Confidence Interval observed in these studies was

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**Table III: ROC-Curve Lintula score diagnostic measures.**

<table>
<thead>
<tr>
<th>Area under the ROC curve</th>
<th>Youden index</th>
<th>Criterion ≤ 21</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUCa</td>
<td>0.963</td>
<td>≤ 21</td>
<td>100%</td>
<td>88.4%</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.007</td>
<td>95% CI 21</td>
<td>0.88</td>
<td>88.4%</td>
</tr>
<tr>
<td>95% CIb</td>
<td>0.94 to 0.97</td>
<td>J valuec</td>
<td>0.84 to 0.91</td>
<td></td>
</tr>
<tr>
<td>Z statistic</td>
<td>59.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance level P</td>
<td>&lt; 0.0001</td>
<td>95% CIb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0.928 by Konan et al., and 0.922 by Yoldas et al., respectively. In this study, the area under the curve was 0.963.

The study represents findings from a single surgical setup and appendectomy status as true or negative was determined by per-operative findings only. Further research needs to be carried out in this regard to validate the effectiveness of the Lintula score in reducing the negative appendectomy rate in the adult population.

CONCLUSION

The Lintula score has high sensitivity, specificity, positive and negative predictive values and overall accuracy. Use of the Lintula score in the diagnosis of acute appendicitis in the adult population increases clinical accuracy and reduces the negative appendectomy rate. This results in a decrease in unnecessary admissions, the healthcare burden and cost and increases the overall efficiency of emergency surgical services.

REFERENCES


