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RESEARCH ARTICLE

CLINICO-RADIOLOGICAL DIAGNOSIS OF APPENDICITIS

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Abstract

Background : The symptom of right lower quadrant pain had puzzled clinicians for many centuries. Appendicitis needs to be considered in the differential diagnosis of nearly every patient presenting with acute abdomen, misdiagnosis of appendicitis is significantly higher in females. Early diagnosis remains the most important goal in patients, despite use of ultrasonography, CT scanning and diagnostic laparoscopy the rate of misdiagnosis of appendicitis and rate of negative appendectomy is significantly high. Surgical treatment is a highly successful medical intervention In this study we have attempted to find a co-relation between the efficiency of clinical diagnosis with radiological diagnosis of appendicitis.

Aim and Objectives: To determine the sensitivity, specificity and diagnostic accuracy of clinical scores, ultrasonography and CT of abdomen in a case of acute appendicitis.

Materials and Method: 50 patients with acute onset lower abdominal pain and diagnosed as appendicitis were evaluated by the emergency surgical team. A detailed clinical evaluation was carried out as per criteria of the three clinical scores (Alvarado, Fenyo, Ohman). The inference from each of the scores was noted. The patients underwent ultrasonography (USG) and contrast CT of the abdomen and pelvis. The findings of both these investigations and intra operative findings were noted. The specimen was sent for histopathological examination which was considered as gold standard for the diagnosis of acute appendicitis.

Result: In this study we found that Alvarado score had the highest sensitivity among females 92.31% and also the highest NPV 66.67%. Ohmann score had the overall highest sensitivity 100% and NPV Hence, it can be used as a simple, quick and effective screening score for detection of appendicitis in a large number of patients. The score is simple to use and can also be calculated by paramedical staff. USG of the abdomen is a useful screening tool however CT had a high specificity 88.89% and PPV 97.30% and diagnostic accuracy of 88%.

Conclusion: Despite the advent of various investigation modalities, a surgeon's clinical acumen should never be compromised. The clinical scores and investigations should always be used as an adjunct history taking and clinical examination. Appendicitis should always be considered as a differential diagnosis in every case of acute pain abdomen.

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Introduction:-

The symptom of right lower quadrant pain had puzzled clinicians for many centuries. The appendix was not identified as an organ capable of causing disease until the 19 century. In textbook titled Elements of Practical Medicine published in 1839, the symptoms of appendicitis was described differentiating it from typhilitis or perityphlitis (inflammation of the caecum) as a primary cause for inflammation in the right lower quadrant. Reginald Fitz in his landmark paper in 1886 first coined the term "appendicitis".¹ The greatest contributor to the advancement in treatment of appendicitis is Charles Chester McBurney, he described the indication of early laprotomy as 'treatment for acute appendicitis.'

Appendicitis needs to be considered in the differential diagnosis of nearly every patient presenting with acute abdomen.³ Appendicitis is most frequently seen in patients in their second through fourth decade of life, which comprises the working age group. Appendectomy is the most commonly performed abdominal surgery in emergency setting. The rate of appendectomy for appendicitis has remained constant 10 per 10,000 patients per year.⁴ However, the rate of misdiagnosis of appendicitis has also remained constant along with the rate to appendiceal rupture. The rate of negative appendectomy is also considerably high with a peak of 23.2% in females. The percentage of misdiagnosis of appendicitis is significantly higher in females.

Early diagnosis remains the most important goal in patients with suspected appendicitis and can be made on the basis of history and physical examination in most cases. However, there is a need for other diagnostic modalities to supplement clinical diagnosis in equivocal cases of acute abdomen presenting with right lower quadrant pain.

Despite the use of ultrasonography, computed tomography (CT) scanning and diagnostic laparoscopy the rate of misdiagnosis of appendicitis and rate of negative appendectomy is significantly high. Surgical treatment of acute appendicitis is a highly successful medical intervention.

However, the inherent risk of surgical complications cannot be discounted.⁵ Furthermore, surgical procedures and aftercare services occur at a considerable cost. The treating clinician therefore is faced with the need to balance the considerable morbidity and even mortality associated with missed diagnosis with exposing the patient to unnecessary surgery and associated morbidity and mortality as a result of positive diagnosis.

Hence, there is a need for a revision in the protocol of diagnosis of appendicitis. In my study I have attempted to find a co-relation between the efficiency of clinical diagnosis with radiological diagnosis of appendicitis. Thereby, to substantiate or negate the need for a change in the protocol of diagnosis of appendectomy in an Indian setup

Aims and Objectives:-

1. To determine the sensitivity, specificity and diagnostic accuracy of clinical scores in a case of acute appendicitis.
2. To determine the sensitivity, specificity diagnostic accuracy of ultrasonography of the abdomen in a case of acute appendicitis.
3. To determine the sensitivity, specificity diagnostic accuracy of computed tomography of the abdomen in a case of acute appendicitis.

Material & Methods:-

Prospective study of 50 patients presenting in the emergency department of a tertiary hospital in Navi Mumbai from May 2009 -December 2011.

Inclusion Criteria

- Patients presenting with pain in right lower quadrant of abdomen

Exclusion Criteria

- Patients below the age of 14yrs.
- Pregnant women.

Study protocol

1. All patients with acute onset lower abdominal pain were evaluated by the emergency surgical team.
2. Routine hematological and biochemical blood investigations and necessary radiological. Investigations done, if a decision to perform an emergency appendectomy was taken, the investigator was informed.
3. A detailed independent clinical evaluation was carried out by the investigator as per criteria of each of the three clinical scores (Alvarado, Fenyo).
4. The inference from each of the scores was noted.
5. The patients underwent ultrasonography(USG) of the abdomen and pelvis, in case it was not done previously.
6. The patients underwent focused appendiceal CT without administration of oral, intravenous or rectal contrast material.
7. The findings of both these investigations were noted.
8. The intra operative findings were noted.
9. The specimen was sent for histopathological examination which was considered as gold standard for the diagnosis of acute appendicitis.
10. Appropriate statistical tools were used for data analysis using SPSS software.

The following definitions were used for recording the symptoms:

• **Migration of pain to the right lower quadrant:**

Pain starting either in the epigastric region, centrally or in the whole abdomen, eventually migrating down to the right iliac fossa.

• **Pain aggravated by coughing:**

The patient was instructed to cough, and any worsening of the pain was registered.

• **Rebound tenderness:**

Elicited in the right lower quadrant when a hand pressing the abdomen for 10-15 sec was suddenly withdrawn.

• **Rigidity:**

Involuntary contraction of the abdominal muscles.

Ultrasonographic criteria for diagnosing acute appendicitis

All sonographic examinations were performed with a handheld 5-MHz linear array with transverse and longitudinal graded compression sonography. The establishment of the diagnosis of acute appendicitis was based on the finding of a positive sonographic McBurney sign, a blind-ending tubular structure greater than 6 mm in outer diameter, the noncompressibility of the appendix, the increased flow signals in the appendiceal wall or periappendiceal space using color Doppler sonography, and the echogenic periappendiceal inflammatory fat change.

Computed Tomography (CT) of the abdomen was done in all patients using focussed appendiceal visualization technique without the administration of any contrast material. This includes taking limited 3mm cuts of the lower abdomen. The CT abdomen findings were noted

Acute appendicitis was diagnosed only on histopathological grounds according to the following criteria:

- Macroscopic signs: intravascular injection of the serosa; fibrinous, purulent film; edematous, hemorrhagic, necrotic changes of the wall; and blood (not sufficient) or pus on opening of the appendix;
- Microscopic signs: focal or expanded erosion, ulceration, abscess, fistula, necrosis, or perforation

The outcome criteria were the diagnostic accuracy of the final examiner with respect to appendicitis sensitivity, specificity, positive and negative predictive value, and accuracy, the perforated appendix rate, the rate of appendectomy with normal findings, the complication rate.

For the outcome criteria, the following definitions were used:

- Perforated appendix rate: Proportion of patients with acute appendicitis who had a histologically proved perforation
- Negative appendectomy rate: Proportion of patients with appendectomy in whom no appendicitis was found.

Results:-

The data collected from 50 patients was analyzed. Most of the patients were 20-40 yrs of age. There were 33 male and 17 female patients. There is no significant difference in the incidence in males and females. Of the 50 patients

operated for appendicitis, 41 patients had a positive histopathology report of acute appendicitis and 9 patients had a normal appendix report. Hence our negative appendectomy rate was 18%.

Of the 33 male patients explored, 28 had a histopathology report of acute appendicitis and 5 had a report of normal appendix.

Thus, the negative appendectomy rate in males in our institute was 15.15%.

Of the 17 female patients explored, 13 had a histopathology report of acute appendicitis and 4 had a report of normal appendix.

Hence the negative appendectomy rate in females was 23.53%. All the females belonged to child bearing age group.

Association between Alvarado score, histopathology and sex in the diagnosis of acute appendicitis in the study group

Table 1:- Association between Alvarado score, sex and histopathology.

Sex	Alvarado Score		Histopathology		Total
			Yes	No	
Male	Yes	Count	20	3	23
		Percent	87%	13%	100%
	No	Count	8	2	10
		Percent	80%	20%	100%
	Total	Count	28	5	33
	Percent	84.8%	15.2%	100%	
Female	Yes	Count	12	2	14
		Percent	85.7%	14.3%	100%
	No	Count	1	2	3
		Percent	33.33%	66.67%	100%
	Total	Count	13	4	17
	Percent	76.5%	23.5%	100%	

Sex	Chi Square Test	Value	Df	P Value	Association
Male	Pearson Chi- Square	0.262	1	0.609	Not Significant
	Fischer's Exact Test			0.627	Not Significant
Female	Pearson Chi- Square	3.767	1	0.052	Not Significant
	Fischer's Exact Test			0.121	Not Significant

b. 2 cells (50.0%) have expected count less than 5.

c. 3 cells (75.0%) have expected count less than 5.

Measure	Estimate	95% Confidence Interval	
		Lower	Upper
Sensitivity	87.80	74.46	94.68
Specificity	88.89	56.5	98.01
PPV	97.30	86.18	99.52
NPV	61.54	35.52	82.29
Diagnostic Accuracy	88	76.19	94.38

Association between Fenyo score, histopathology and sex in the diagnosis of acute appendicitis in the study group

Table 2:- Association between Fenyo score, sex and histopathology.

Sex	Alvarado Score		Histopathology		Total
			Yes	No	
Male	Yes	Count	20	3	23
		Percent %	87%	13%	100%

	No	Count	8	2	10
		Percent %	80%	20%	100%
	Total	Count	28	5	33
		Percent %	84.8%	15.2%	100%
Female	Yes	Count	3	1	4
		Percent %	75%	25%	100%
	No	Count	10	3	13
		Percent %	76.9%	23.1%	100%
	Total	Count	13	4	17
		Percent %	76.5%	23.5%	100%

Sex	Chi Square Test	Value	Df	P Value	Association
Male	Pearson Chi- Square	0.262	1	0.609	Not Significant
	Fischer’s Exact Test			0.627	Not Significant
Female	Pearson Chi- Square	0.006	1	0.937	Not Significant
	Fischer’s Exact Test			1.000	Not Significant

- b. 2 cells (50.0%) have expected count less than 5.
- c. 3 cells (75.0%) have expected count less than 5.

Measure	Male	Female
Sensitivity	71.43	92.31
Specificity	40	50
PPV	86.96	85.71
NPV	20	66.67
Diagnostic Accuracy	66.67	82.35

Association between Ohmann score, histopathology and sex in the diagnosis of acute appendicitis in the study group

Table 3:- Association between Ohmann score, sex and histopathology.

Sex	Alvarado Score		Histopathology		Total
			Yes	No	
Male	Yes	Count	28	3	31
		Percent %	90.3	9.7	100
	No	Count	0	2	2
		Percent %	0	100	100
	Total	Count	28	5	33
		Percent %	84.8	15.2	100
Female	Yes	Count	13	4	17
		Percent %	76.5	23.5	100
	Total	Count	13	4	17
		Percent %	76.5	23.5	100

Chi Square Test	Value	Df	P Value	Association
Pearson Chi- Square	11.932	1	0.001	Significant
Fischer’s Exact Test			0.019	Significant

- b. 3 cells (75.0%) have expected count less than 5
- c. No statistics are computed because Ohmann score is a constant.

Association between Ultrasonography of abdomen, histopathology and sex in the diagnosis of acute appendicitis in the study

Table 4:- Association between USG, sex and histopathology.

Sex	Alvarado Score		Histopathology		Total
			Yes	No	
Male	Yes	Count	5	3	8

		Percent %	62.5	37.5	100
	No	Count	23	2	25
		Percent %	92	8	100
	Total	Count	28	5	33
		Percent %	84.8	15.2	100
Female	Yes	Count	5	4	9
		Percent %	55.6	44.4	100
	No	Count	8	0	8
		Percent %	100	0	100
	Total	Count	13	4	17
		Percent %	100	23.5	100

Sex	Chi Square Test	Value	Df	P Value	Association
Male	Pearson Chi- Square	4.103	1	0.043	Significant
	Fischer’s Exact Test			0.078	Not Significant
Female	Pearson Chi- Square	04.650	1	0.031	Significant
	Fischer’s Exact Test			0.082	Not Significant

- b. 2 cells (50.0%) have expected count less than 5.
- c. 2 cells (50.0%) have expected count less than 5.

Measure	Male	Female
Sensitivity	17.86	38.46
Specificity	40	0
PPV	62.5	55.56
NPV	8	0
Diagnostic Accuracy	21.21	29.41

Association between CT scan abdomen, sex and histopathology in the diagnosis of acute appendicitis in the study group

Table 5:- Association between CT, sex and histopathology.

Sex	Alvarado Score		Histopathology		Total
			Yes	No	
Male	Yes	Count	25	1	26
		Percent %	96.2	3.8	100
	No	Count	3	4	7
		Percent %	42.9	57.1	100
	Total	Count	28	5	33
		Percent %	84.8	15.2	100
Female	Yes	Count	11	0	11
		Percent %	100	0	100
	No	Count	2	4	6
		Percent %	33.3	66.7	100
	Total	Count	13	4	17
		Percent %	100	23.5	100

Sex	Chi Square Test	Value	Df	P Value	Association
Male	Pearson Chi- Square	12.186	1	0.000	Significant
	Fischer’s Exact Test			0.004	Significant
Female	Pearson Chi- Square	9.590	1	0.002	Significant
	Fischer’s Exact Test			0.006	Significant

- b. 2 cells (50.0%) have expected count less than 5.
- c. 3 cells (75.0%) have expected count less than 5.

Measure	Male	Female
Sensitivity	89.29	84.62
Specificity	80	100
PPV	96.15	100
NPV	57.14	66.67
Diagnostic Accuracy	87.88	88.24

Annexure

Chart 1:- Incidence of appendicitis in male and female patients.

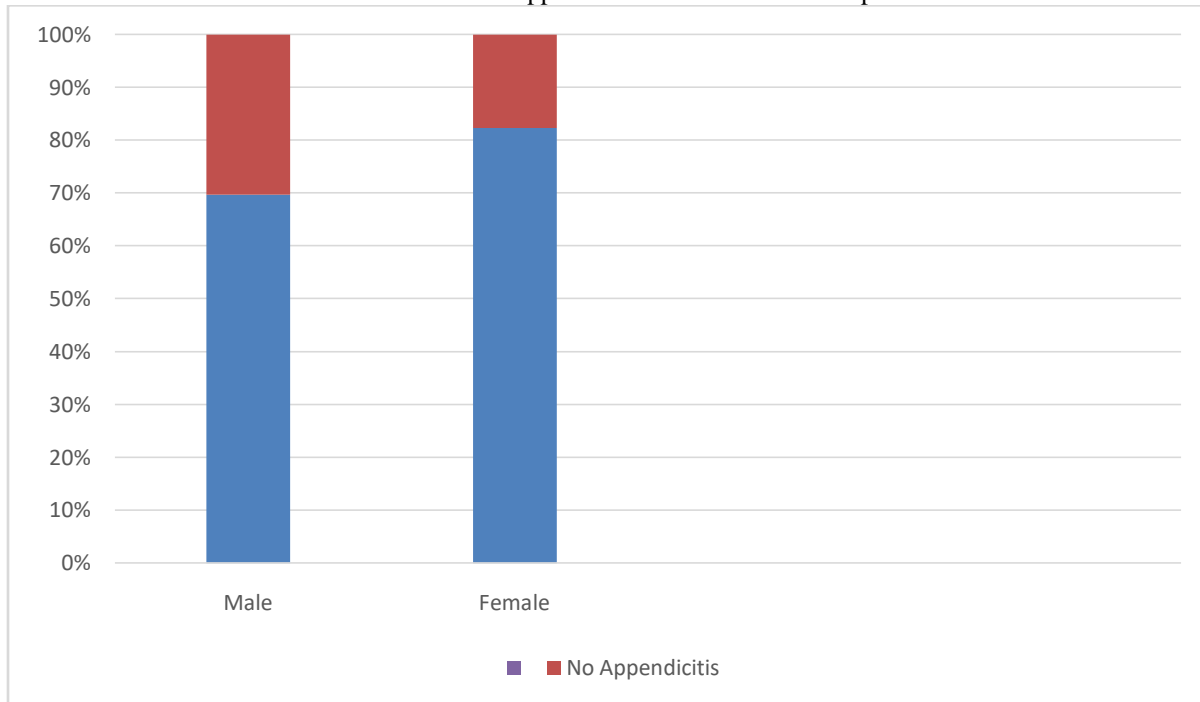


Chart 2:- Association of Alvarado Score, Sex and histopathological findings in study group.

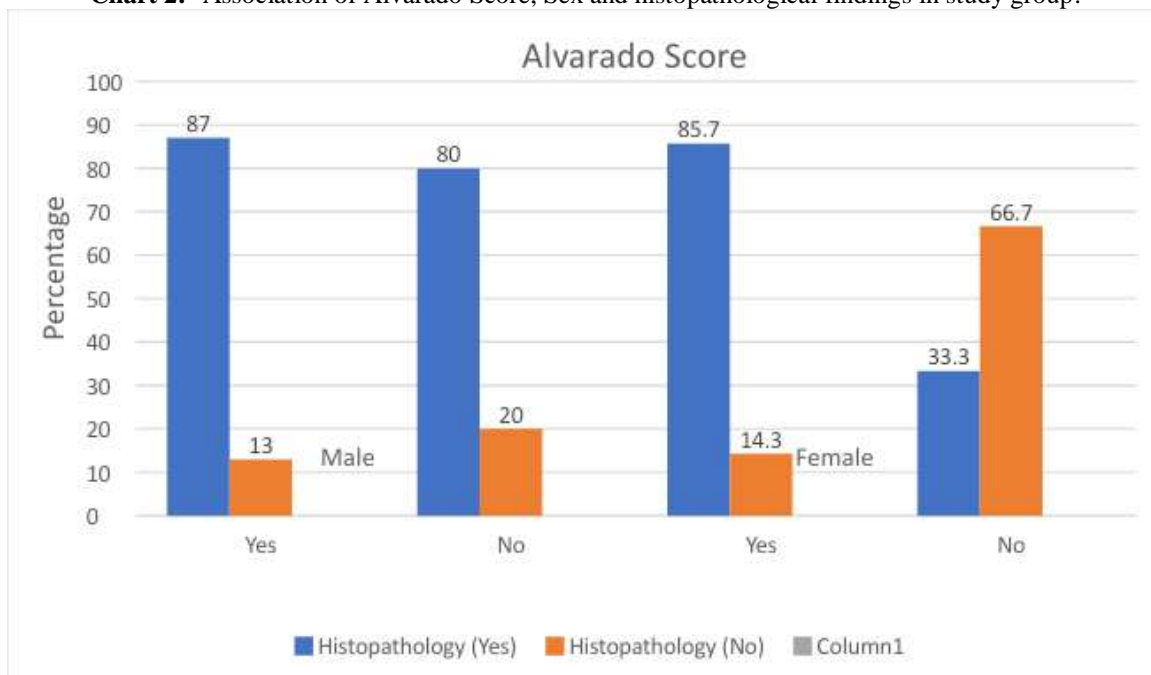


Chart 3:- Association of Fenyo Score, Sex and histopathological findings in study group.

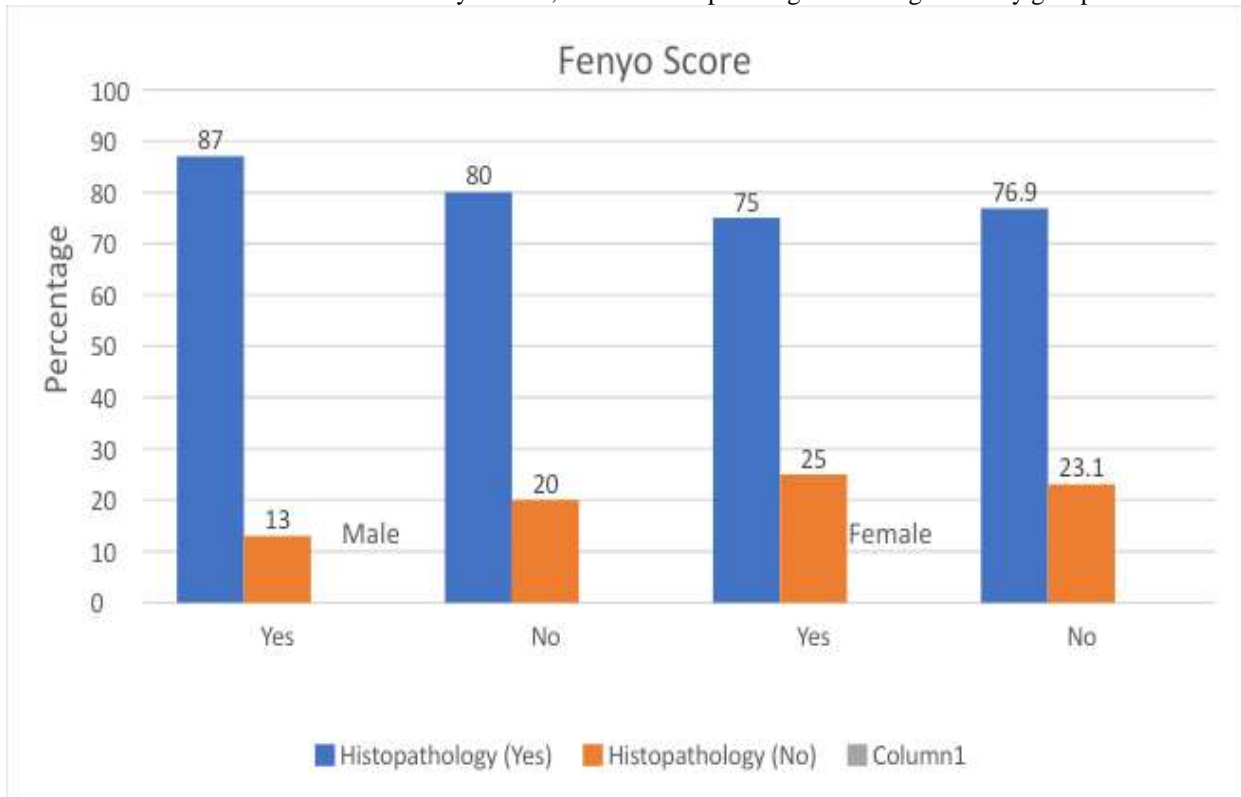


Chart 4:- Association of Ohmann Score, Sex and histopathological findings in study group.

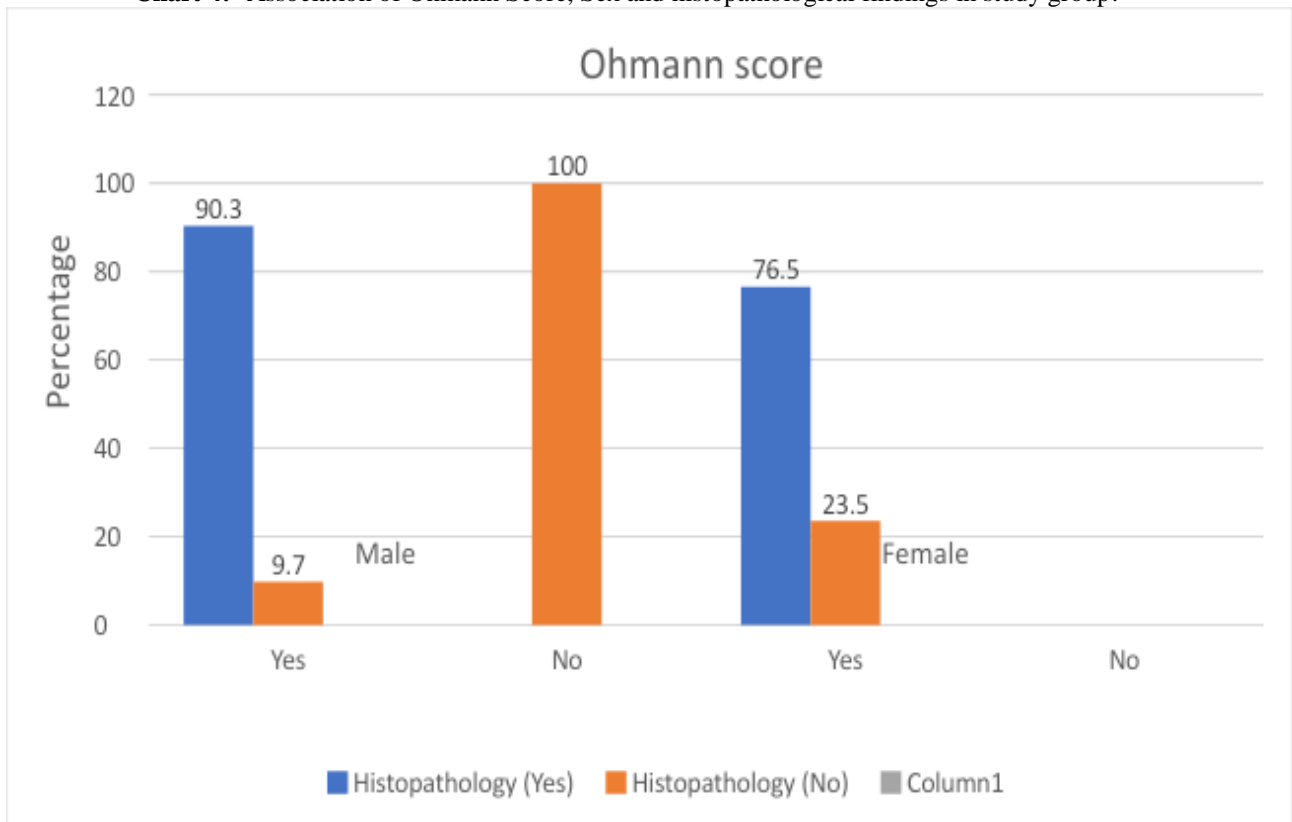


Chart 5:- Association of USG, Sex and histopathological findings in study group.

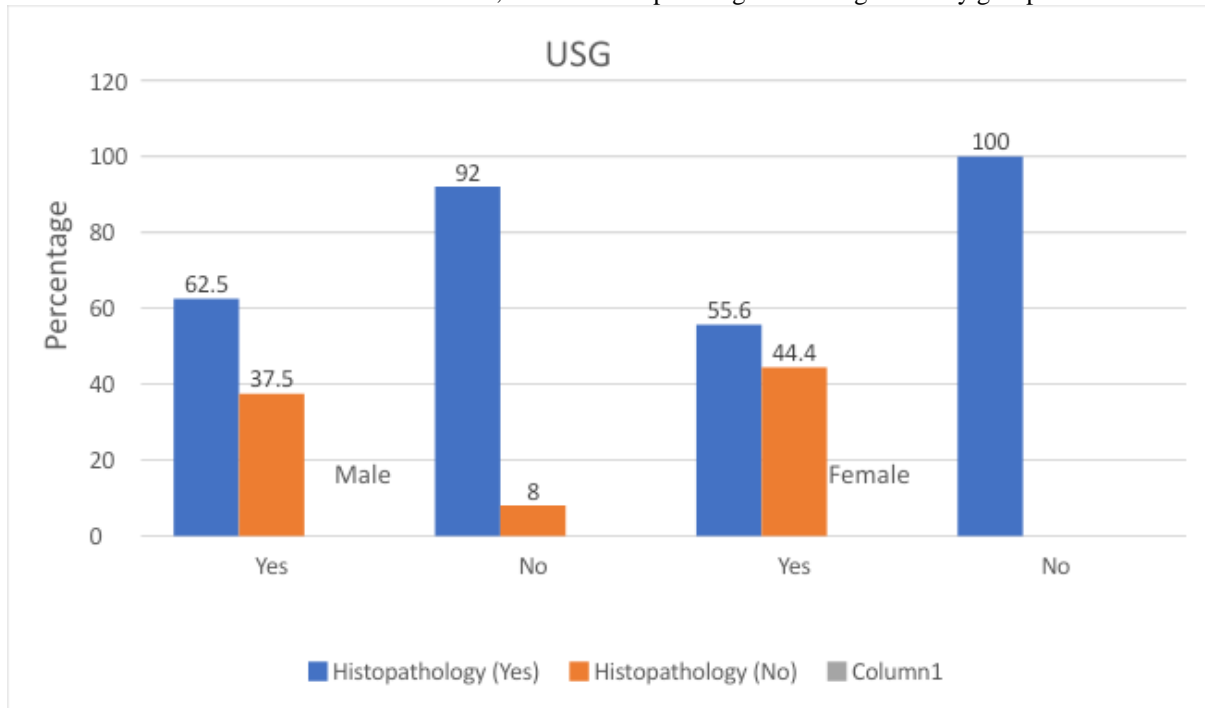
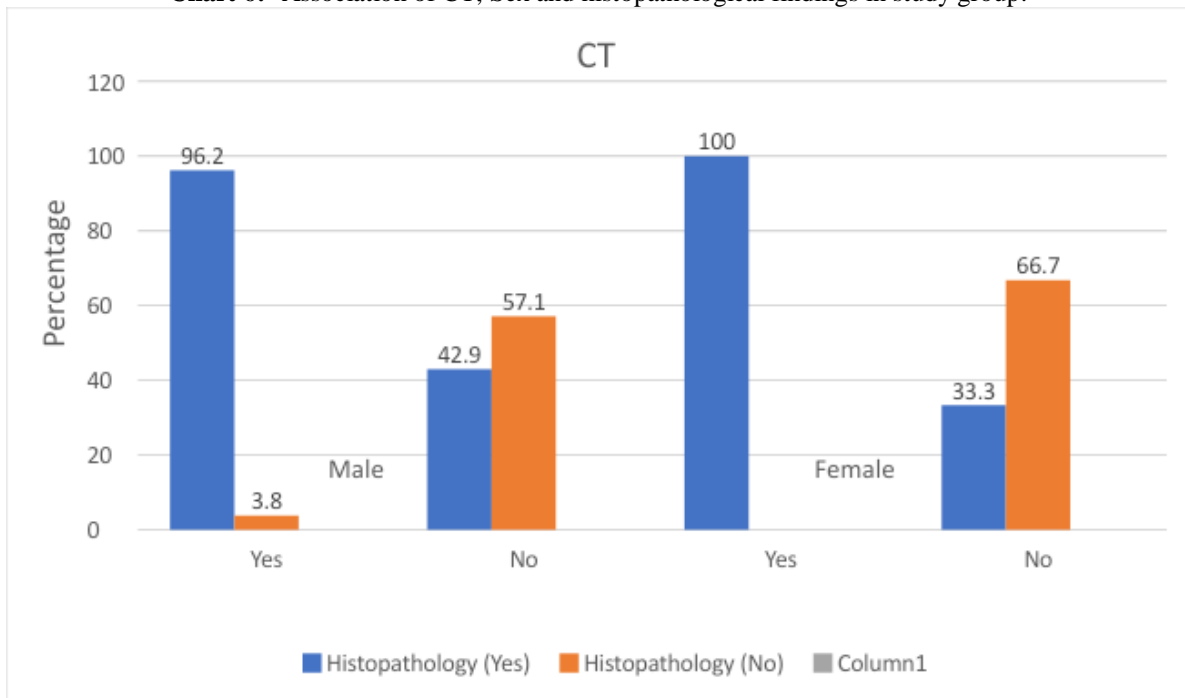


Chart 6:- Association of CT, Sex and histopathological findings in study group.



Discussion:-

Despite improvement in imaging techniques and laboratory investigations, routine diagnosis of acute appendicitis still poses a challenging problem. The major area of concern worldwide are the rate of negative appendicectomies (20-30%), perforated appendix (15-20%), delayed operations and longer hospital stay due to delay in diagnosis. Over the years, several diagnostic scoring systems have been evolved so as to aid the clinician in making a quick decision. Various imaging modalities have been employed for the visualization of the inflamed appendix.

We, in our study have aimed at studying the pattern of this extremely common disease. We have evaluated the usefulness of these scores and imaging modalities in an Indian setup in the diagnosis of acute appendicitis.

We found that maximum number of patients belonged to 20-30 age group. The incidence of appendicitis increases as the age increases. There is no significant difference in the incidence among males and females. Of our 50 patients 9 were found to have a normal appendix. Thus, we had a negative appendicectomy rate of 18%.

Our rate of complication was 14.63%. Of the 6 patients that had a complication only 2 were < 40 yrs whereas 4 were > 40 yrs. Thus, the incidence of complications due to appendicitis in patients > 40 yrs was 57.14% as compared to 5.88% among patients < 40 yrs of age. This indicates the need for early diagnosis and surgical intervention if appendicitis is suspected in elderly patients. Atypical presentation has been common in this age group. CT scan has been shown to be sensitive in diagnosis such atypical cases.

The simplicity of a score for acute appendicitis is quite appealing. The idea of improving the diagnostic accuracy simply by assigning numeric values to defined signs and symptoms has been a goal in some of the scores described. Parameters comprising the score usually include general signs of abdominal illness (e.g. type, location and migration of pain, body temperature, signs of peritoneal irritation, nausea, vomiting etc) as well as routine laboratory findings (leukocytosis).

Such simple scoring systems may work as expected in the original setting, but they do not take into consideration different diagnostic weights of each parameter in different subpopulation (eg. children, women etc). Thus, scores usually did not repeat their good results when applied to different populations, which led to the creation of new scoring systems and their re-evaluation in different settings.

Clinical scoring systems have proved useful in the management of number of surgical conditions. In the past few years various clinical scoring systems have been developed to aid the diagnosis of acute appendicitis including Ohman^{6,7}, Lindberg⁸, Eskelinen^{9,10}, Teicher¹¹ and Alvarado¹². A significant reduction of negative appendicectomy rate to 7.8% was noted in studies when patients were subjected to scoring systems."¹³

Alvarado score

In our study the accuracy of the score was as follows:

Measure	Male (%)	Female (%)	Total (%)
Sensitivity	71.43	92.31	78.05
Specificity	40	50	44.44
PPV	86.96	85.71	86.49
NPV	20	66.67	30.77
Diagnostic Accuracy	66.67	82.35	72

In our study the sensitivity of Alvarado score among female patients was 92.31% which is higher than that obtained in a study conducted by M. Horzic et al (83.3%) in 126 female patients. "The positive predictive value of Alvarado score is 86.96 % for males, 85.71% for females and 86.49% for both. This is comparable to the study conducted by Khan I et al wherein the positive predictive value for Alvarado score was 84.3 % (males 88% and females 82.1%)¹⁴

Alvarado score had a diagnostic accuracy of 82.35% for females which is comparable to a study done by Faran Kiani et al.¹⁵

Fenyo score

In our study the accuracy of the score was as follows:

Measure	Male (%)	Female (%)	Total (%)
Sensitivity	71.43	23.08	56.10
Specificity	40	75	55.56
PPV	86.96	75	85.19
NPV	20	23.08	21.74

Diagnostic Accuracy	66.67	35.29	56
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The sensitivity of Fenyo score was 56,10% and spelley we 3556% which is much lower compared to the original sody conduces by Fenyo et al. ¹⁶ The positive predictive value among females was 75%, which is comparable to a study conducted by Enochsson et all which had a PPV OF 79%. The overall PPV value in their study was; which is comperable to our PPV OF 86.96% ¹⁷

Ohmann score

In our study the accuracy of the score was as follows:

Measure	Male (%)	Female (%)	Total (%)
Sensitivity	100	50	100
Specificity	40	50	22.22
PPV	90.32	76.47	85.42
NPV	100	23.53	100
Diagnostic Accuracy	90.91	50	86

In our study Ohmann score had a sensitivity of 100% and a negative predictive value of 100% for male patients which is comparable to the study conducted by Nagarajan G and Subramanyam P which had a sensitivity of 94.4% and a NPV of 87.5% among male patients. ¹⁸

The specificity of Ohmann score among female patients was 50%, the PPV is 76.47% and diagnostic accuracy is 50% which is comparable to the study conducted by Horzic et al which had a specificity of 33.3%, a PPV of 86.5% and a diagnostic accuracy of 66.4%. ¹⁹

In our study the sensitivity is 100%, the NPV IS 100% and the and the diagnostic accuracy is 86% which is comparable to the original study by Ohmann et al which had a sensitivity of 91.5%, NPV of 97.2% and diagnostic accuracy of 87.6%. ²⁰

Ultrasonography

In our study the accuracy of the score was as follows:

Measure	Male (%)	Female (%)	Total (%)
Sensitivity	17.86	38.46	24.39
Specificity	40	0	22.22
PPV	62.50	55.56	58.82
NPV	8	0	6.06
Diagnostic Accuracy	21.21	29.41	24

Since Puylaert emphasized that sonographic visualization of the appendix was the sole indicator for diagnosis of acute appendicitis in his original description of graded compression sonography, many studies have used graded compression sonography for a diagnosis of appendicitis with sensitivities and specificities of more than 90% if an experienced examiner performed the examination. ²¹⁻²⁵

Our study had results which are not comparable to standard results, This shows that although USG is a highly recommended tool in the diagnosis of acute appendicitis, it is highly operator dependant and results will vary from one centre to the other.

Computed Tomography

In our study the accuracy of the score was as follows:

Measure	Male (%)	Female (%)	Total (%)
Sensitivity	89.29	84.62	87.80
Specificity	80	100	88.89

PPV	96.15	100	97.30
NPV	57.14	66.67	61.54
Diagnostic Accuracy	87.88	88.24	88

The overall sensitivity of CT scan appendix was 87.80%, specificity was 88.89% and PPV was 97.30% which is comparable to studies done by Lane et al²⁶, Wise et al²⁷, Cakirer et al²⁸ using focused appendiceal CT without the use of oral, intravenous or rectal contrast.

Helical CT has proven to be an effective and accurate means of diagnosing acute appendicitis, with reported sensitivities of 90-100%, specificities of 91-99%, accuracies of 94-98%, positive predictive values of 92-98%, and negative predictive values of 95-100%²⁹⁻³²

CT scan of the abdomen in our study showed a specificity of 100% in female patients, hence CT scan is a very useful modality that can be used in the reduction of negative appendectomy cases among females. Our study also shows a PPV of 100% among females which helps in reducing the delay in diagnosis and subsequent treatment in these patients.

Studies comparing the use of sonography with CT in patients suspected of having acute appendicitis have generally favored CT for providing greater diagnostic accuracy, superior detection and staging of complications, and higher accuracy for establishing alternative diagnoses.^{28,33-34}

Studies have also shown that CT may help to decrease hospital costs and negative laparotomy rates.^{35,36}
The use of CT scan and USG also helps in establishing alternative diagnosis.^{37,38}

Conclusion:-

In our study we found that Alvarado score had the highest sensitivity among females 92.31% and also the highest NPV 66.67%.

It is therefore a useful score to reduce the number of misdiagnosis among female patients.

Ohmann score had the highest sensitivity of 100% among males and a NPV of 100%. It can therefore be used as a simple score to rule out appendicitis in male patients presenting with abdominal pain.

Ohmann score had the overall highest sensitivity 100% and NPV 100%. Hence, it can be used as a simple, quick and effective screening score for detection of appendicitis in a large number of patients. The score is simple to use and can also be calculated by paramedical staff.

It is useful in reducing the delay in diagnosis and also increased hospital stay.

Fenyo score is comparatively cumbersome to use and had low sensitivity and specificity compared to other scores.

USG of the abdomen is a useful screening tool, however is highly operator dependant and should be used to establish diagnosis and detect alternative diagnosis in equivocal cases.

CT scan had a high specificity 80% and a high positive predictive value 96.15% among males. It also had a specificity of 100%, a PPV of 100% a NPV of 66.67% among female patients.

Overall it had a high specificity 88.89% and PPV 97.30% and diagnostic accuracy of 88%. CT scan helps in reducing the number of negative appendectomies thereby reducing the overall morbidity.

The high cost and limited availability of CT scan in all centres poses a problem especially in a developing country like India.

The use of CT scan should hence be limited to equivocal cases, elderly patients and non - pregnant women. Thereby, attempting to considerably reduce the rate of negative appendectomies.

The discrepancy in some of the results of this study compared to other studies may be because of the limited patients, who are not a true representative of the population. There is a need to conduct large cross sectional studies comparing parameters used in this study to obtain more reliable results.

Despite the advent of various investigation modalities, a surgeon's clinical acumen should never be compromised. The clinical scores and investigations should always be used as an adjunct history taking and clinical examination. Appendicitis should always be considered as a differential diagnosis in every case of acute pain abdomen.

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