"EVALUATION OF PRE-OPERATIVE OUTER DIAMETER OF APPENDIX IN PREDICTING CONVERSION TO OPEN SURGERY IN LAPAROSCOPIC APPENDECTOMY- ONE YEAR OBSERVATIONAL STUDY, AT KAHER'S DR. PRABHAKAR KORE CHARITABLE HOSPITAL AND MEDICAL RESEARCH CENTRE, BELAGAVI-590010."

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LIST OF ABBREVIATIONS.

JNMC	Jawaharlal Nehru Medical College
KAHER	KLE Academy of Higher Education and Research
KLE	Karnataka Lingayat Education
CT	Computed Tomography
USG	Ultrasonography
MRI	Magnetic resonance imaging
PR	Pulse rate
RR	Respiratory rate
BP	Blood Pressure
mm	millimeter
TLC	Total Leucocyte Count
WBC	White Blood Cell
PID	Pelvic Inflammatory Disease
IBD	Inflammatory Bowel Disease
APSI	Appendicitis severity index
US	United states
ANOVA	Analysis of variance
ROC	Receiver operating curve

ABSTRACT

Background: Acute appendix emergencies often surgical intervention, laparoscopy which has become the preferred approach due to its faster recovery, reduced hospital stays, and reduced analgesic need. However, cases like abscess formation or perforated appendix may necessitate an open procedure. This study aims to identify preoperative parameters to predict the risk of converting to an open appendicectomy, thereby improving the decision-making process.

Aim: To find a cut off value of pre operative appendix diameter on imaging to help predict laparoscopic procedure being converted to open procedure.

Materials & Methods: 63 patients were evaluated in an observational study over a period of one year in tertiary care hospital who were admitted with acute appendix and planned for laparoscopic appendicectomy. Diameter of appendix was noted pre-op with imaging and all the procedure converted to open were recorded and statistical analysis done to find the cut off value of the diameter.

Results: From the 63 candidates who underwent laparoscopic appendicectomy, 7 were converted to open procedure. A value of 8.95 mm is considered as a cut-off value for appendix diameter in converted to open cases.

Conclusion: Pre-op diameter of appendix can be one of the parameters that will aid the surgeon predict laparoscopic to open conversion of appendicectomy procedure. According to our study an appendix diameter beyond 8.9mm can directly be approached with open technique.

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INTRODUCTION

Acute appendix is one of the common emergencies in surgery. Open appendix surgery was the only option for many years before advent of laparoscopic appendicectomy. Laparoscopy is now the most preferred approach for operating on an acutely inflamed appendicitis. Its advantages include faster recovery, less duration of stay in the hospital and decreased analgesic need. It provides a complete visualisation of the peritoneal cavity for other pathology. Some cases such as abscess/mass, perforated appendix laparoscopic approach may need to be converted to open procedure. Conversion to open after starting with laparoscopy increases expenses, prolongs the hospital stay and adds to the morbidity. Therefore, predicting pre - operatively the chance of conversion to open surgery will be helpful. There are many factors which may help the surgeon in predicting conversion to open surgery. Diameter of the appendix is one such factor that maybe helpful in guiding the surgeon.

OBJECTIVE OF THE STUDY

To assess pre operative diameter of appendix on USG/CT as a predictor for likely conversion to open surgery

REVIEW OF LITERATURE

The vermiform appendix is a tiny pouch with a blind end that is situated close to the ileocecal junction at the tip of the cecum. "Worm-like" is how the adjective "vermiform" characterizes its thin, tubular shape. Berengario da Carpi wrote the first description of the organ in 1521. In 1736 Amyand Claudious performed the first appendicectomy.

All hominids, including apes and humans, have an appendix. In addition, a cecal appendage is present in a large number of other mammals, such as the wombat and rabbit. The human appendix's physiological role has long been a source of controversy, with many seeing the organ as a remnant of early evolutionary development. There is evidence to the contrary from recent discoveries about the potential immune function of the appendix. The lymphatics of appendix probably helps in controlling the growth of harmful bacteria in the gut. [1]

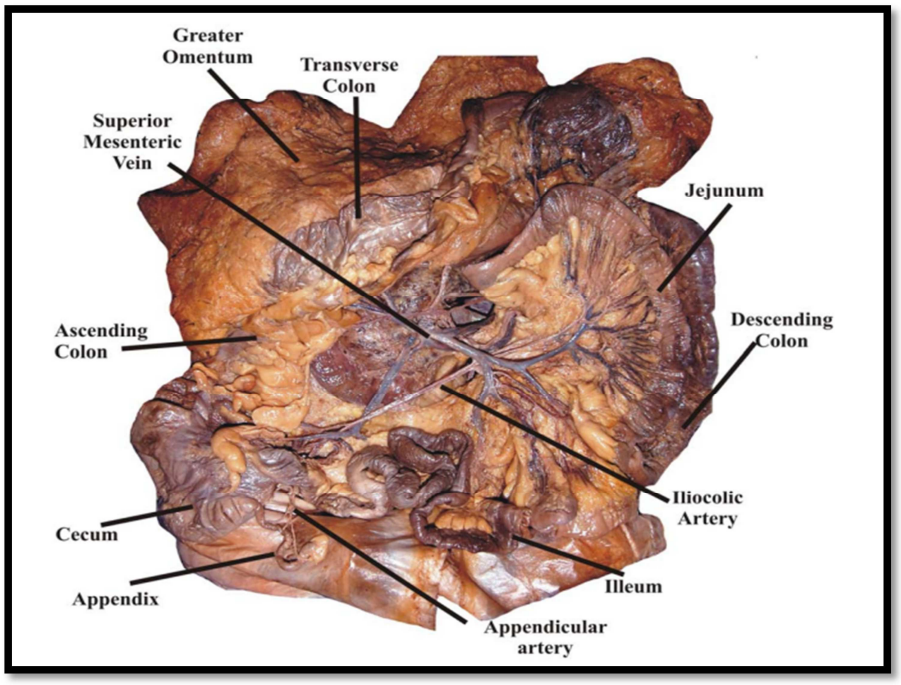


Fig. 1 Cadaveric dissection showing appendix, descending colon

This appendix is known for its pathology; the lifetime risk of developing appendicitis is - 6.7% in women and 8.6% in men.[2] Incidence is high in second and third decade of life.

Mortality rate attributed to acute appendicitis over the past 50 years from nearly 26% to less than 1%. However, the morbidity rate, which has heavily impacted health care costs, has not experienced a similar drop. [25]

Patients with perforated appendicitis had a 72.2% complication rate. Peritoneal collection of more than 150 ml was linked to a 100% increase in morbidity and mortality (54.5%). The mean duration of the hospital stay in patients with a perforated appendix was 7.28±5 days. Surgical site infection (42%) was the most common early complication, followed by wound dehiscence (16.6%), intestinal obstruction (1.6%), and faecal fistula (1.6%). The most common late complications were intestinal obstruction (2.4%), intra-abdominal abscess (1.6%), and incisional hernia (1.6%). The mortality rate in patients with perforated appendicitis was 4.8%. [24]

EMBRYOLOGY

The appendix appears during the eighth week of pregnancy and grows rapidly in length. The appendix initially protrudes from the apex of caecum. As the cecum's right haustrum expands, the appendix shifts medially and upward. [4] The lumen's circular cross section becomes lobed by the twelfth week. In the fourteenth week of development, lymphatics starts to form within appendix. After birth, lymph nodules start to form in the fourth and fifth month and continues to grow until puberty. [3][4]

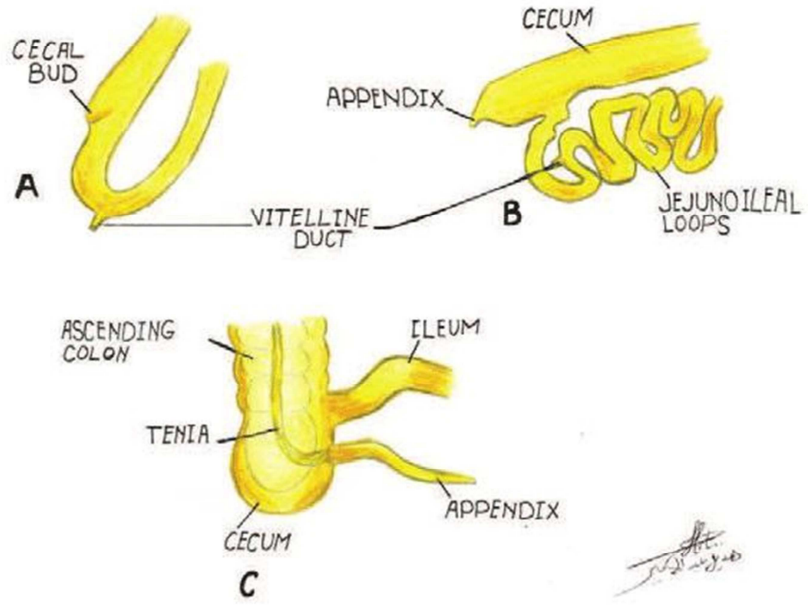


Fig. 2 Development of cecum and appendix

ANATOMICAL CONSIDERATION

The appendix is a tiny, tubular outpouching that is usually found 1.7 cm below the ileocecal valve, at posteromedial wall of the cecum. Appendix measures 8.21 cm on average in length. [7] The mesoappendix, a triangle fold of mesentery that connects to the cecum, is what suspends the appendix from the terminal ileum. Because the mesoappendix is shorter than the appendix, the appendix appears noticeably twisted or curled Normally the proximal end of appendix open 2.5cm lower to the ileo caecal valve into cecum, while the distal appendix lumen is partially occluded. The Gerlach valve, a fold in the mucous membrane, protects this opening. (Davis & Muler, 1910).

The appendix receives its vascular supply from appendicular artery. It then empties into the superior mesenteric vein; consequently, the hepatic portal vein can transport an infection from the appendix straight to the liver. The lymph is drained from the appendix and cecum into the mesoappendix lymph nodes, where it travels from ileocolic artery to the superior mesenteric group lymphatic nodes.[7] Normally, appendix is found in abdomen's right inferior quadrant. The appendix can also be found in the lower midline positions, left anterior para midline, and upper left quadrant. Other positions in which the appendix may be found include pelvic, sub cecal, post ileal, and pre ileal. The cecum's alterations due to posture, breathing, tone of the abdominal muscles, and the amount of distention of nearby bowel too affect how appendix is positioned within the abdominal cavity. [3]

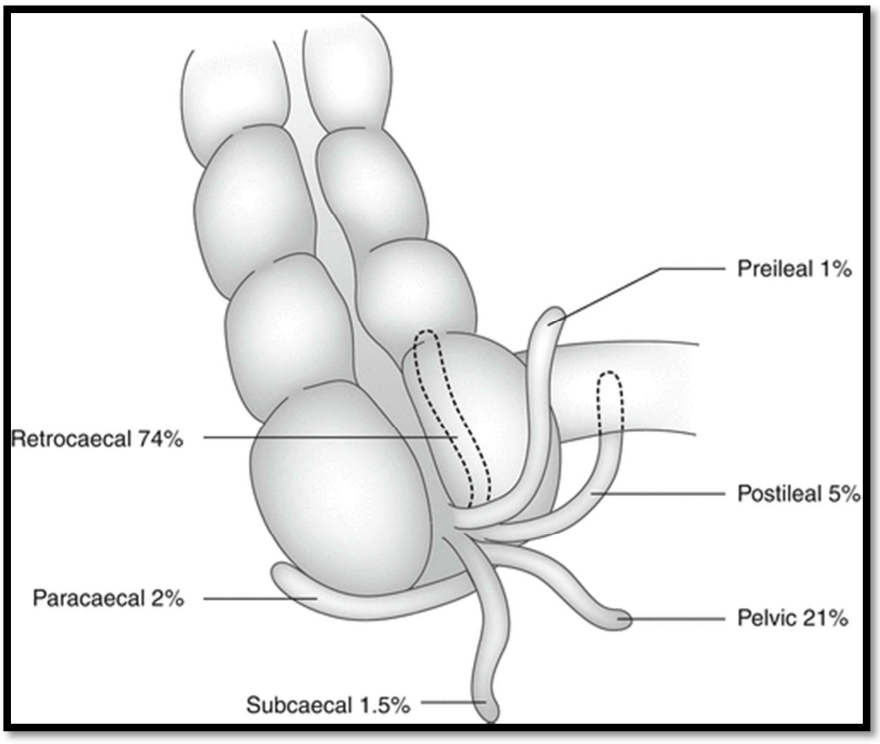


Fig. 3 Position of appendix

APPENDICITIS

AETIOLOGY AND PATHOPHYSIOLOGY:

Though a common consensus for a single etiology of appendicitis is not yet achieved, several conditions, i.e. fecolith (most common) or lymphoid hyperplasia or edema followed by secondary bacterial invasion, causes eventually the obliterations of appendiceal lumen and progressing to congestion and gangrenous changes prior to perforation. Speculations/ Hypothesis have been many at times proposed, yet these have only to been recognized as contributary factors. Most notably, reduced intake of dietary fiber, increased consumption of refined carbohydrates, special mention regarding helminthic infestations such as Oxyuris vermicularis (synonym: pinworm).

Being the inflammation of appendix, two contrasting forms of pathogenesis have been explained:

- *Obstructive Appendicitis-* due to any cause of luminal obstruction, may it be from the more common cause of fecal stasis to rarely such as foreign body or neoplasia, is followed by an unopposed secretion of mucin within the appendix, resulting in an increase in luminal pressure also growth of pathogenic microorganisms within these secretions leading to an inevitable reduction in venous flow followed by arterial occlusion. These mentioned environments promote necrosis and bacterial translocation into the appendiceal walls to form the titular gangrenous appendicitis. In a lack of timely intervention these appendices will rupture to turn into abscesses, leading to localized leading to generalized peritonitis.

- *Catarrhal Appendicitis:* an ailment confined only to the mucosal layer of the appendix. This is a milder version of an attack of appendicitis having a much lower incidence of perforation thus lower complication rates. It is postulated towards an infective agent possibly viral in origin to be the cause of such an appendicitis. During its initial development the appendix would appear normal or hyperemic, yet its mucosa is thickened and edematous. On progression patchy ulcers over the mucosal surface starts to ulcerate causing the appendix to swell and have its serosa become roughly coated with exudative collection. In most instances this form of appendicitis resolves spontaneously and rarely enters into gangrenous transformation. One must still bare head to the fact that repeated such episodes may form strictures, kinks on the appendix which can precipitate into obstructive appendicitis.

Most frequently encountered acute abdomen surgical condition is appendicitis. Appendix is more prone to inflammation due to its tubular, blind-ending lumen, high lymphatic tissue content, & propensity to become obstructed by fecaliths. Mucus and other fluids are prevented from leaving the lumen of appendix through occlusion, thereby causing distension and inflammation. Blood vessels occlude as luminal pressure rises, resulting in ischemia and eventually necrosis. When appendix is in impending rupture there is release of pathogens in the peritoneal cavity, which can turn into a surgical emergency. [3]

The mortality rate from nonperforated appendicitis is less than 1%. Delay in diagnosis leads to perforation of appendix which increases the mortality by nearly five times. Confirming a positive diagnosis requires a thorough, thoughtful physical examination. Tenderness in the right inferior quadrant is the most crucial indicator of acute appendicitis. When a patient is in the left lateral posture and extends the

patient's right thigh, stretching the iliopsoas muscle, this indicates an inflamed appendix. The "psoas sign," which is pain felt during this manoeuvre, may point to the appendix's retrocecal location. Similarly, stretching of the obturator internus through internal rotation of a flexed thigh (obturator sign) suggests inflammation near the muscle. On deep palpation, one can often feel a muscular resistance (guarding) in the right iliac fossa, which may be more evident when compared to the left side. When the pressure of the examining hand is quickly relieved, the patient feels a sudden pain, the so-called rebound tenderness. Indirect tenderness (Rovsing's sign) and indirect rebound tenderness (i.e., pain in the right lower quadrant when the left lower quadrant is palpated) are strong indicators of peritoneal irritation. Gangrenous appendicitis is sometimes accompanied by hyperesthesia (Ligats's sign) in Sherren's triangle (bound by the lines connecting the umbilicus, right anterior superior iliac spine, and symphysis pubis). (Schwartz, 1994)

If an appendicitis diagnosis cannot be made solely by physical examination, laboratory and radiological diagnostics may be useful. In 80% of acute appendicitis, there is a total leukocyte count (TLC) > 10,000/mm3. According to Schwartz (1994), counts between 10,000 and 18,000/mm3 are suggestive of uncomplicated appendicitis, while counts exceeding 18,000/mm3 may indicate a perforation. Close to 70% of patients with right inferior quadrant pain due to various causes may have an elevated WBC count; however, this has a low-predictive value. In addition to confirming the diagnosis of appendicitis, diagnostic imaging is crucial for ruling out other pathologies. [11]

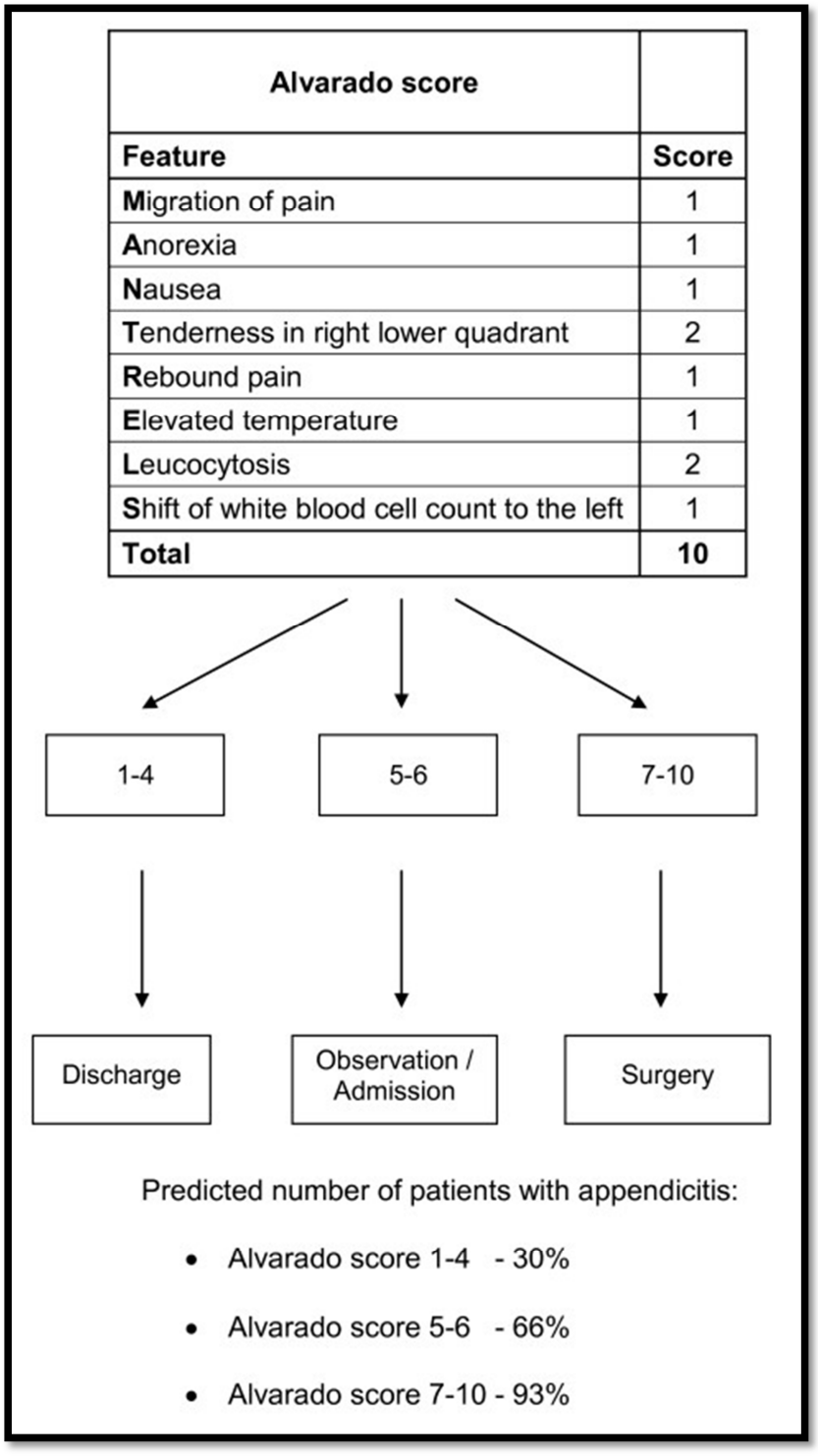
In most cases, sonography combined with computed tomography (CT) imaging is a more accurate diagnostic tool for acute appendicitis than plain X-ray imaging. When determining the diameter of a normal appendix—which is 6 mm or

less—ultrasonography is useful. The diameter of an inflamed appendix is typically larger than 6mm. However, other disorders in the right inferior quadrant, such as endometriosis, pelvic inflammatory disease (PID), diverticulitis of cecum, inflammatory bowel disease (IBD), and Meckel's diverticulum, can cause false-positive results on ultrasonography. Because CT is better at identifying a normal appendix than ultrasonography, it has been found to be a more accurate imaging tool for diagnosing acute appendicitis. The sensitivity of CT scan is 90–100%, as opposed to 85% with ultrasonography. [9][10]

The clinical diagnosis of appendicitis is a subjective assessment based on a number of variables that are poor discriminators. Clinical scoring systems, which are based on variables with established discriminating power, can help to make this process more objective.

The most popular scoring system is the Alvarado score. It is particularly helpful in ruling out appendicitis and choosing which patients require additional diagnostic testing. [22][23]

Table 1: Alvardo scoring system



IMAGING CRITERIA FOR APPENDICTIS

A positive McBurney sign (probe tenderness), a blind-ending hollow structure larger than 6mm in its outer diameter, non-compressibility of appendix, increased vascular flow in the appendiceal wall or peri appendiceal space using colour doppler, echogenic peri appendiceal fat stranding, periappendiceal free gas, and abscess are all used to establish acute appendicitis. The most crucial diagnostic factor in the appendix's assessment is its outer diameter. When identifying acute appendicitis, an outer appendicular diameter of 6mm or greater yields high sensitivity but low specificity, whereas a diameter of 7mm or greater yields lower sensitivity but a higher accuracy and also specificity.[12] It is believed that optimal compression should come before measuring the vermiform appendix's outer diameter.

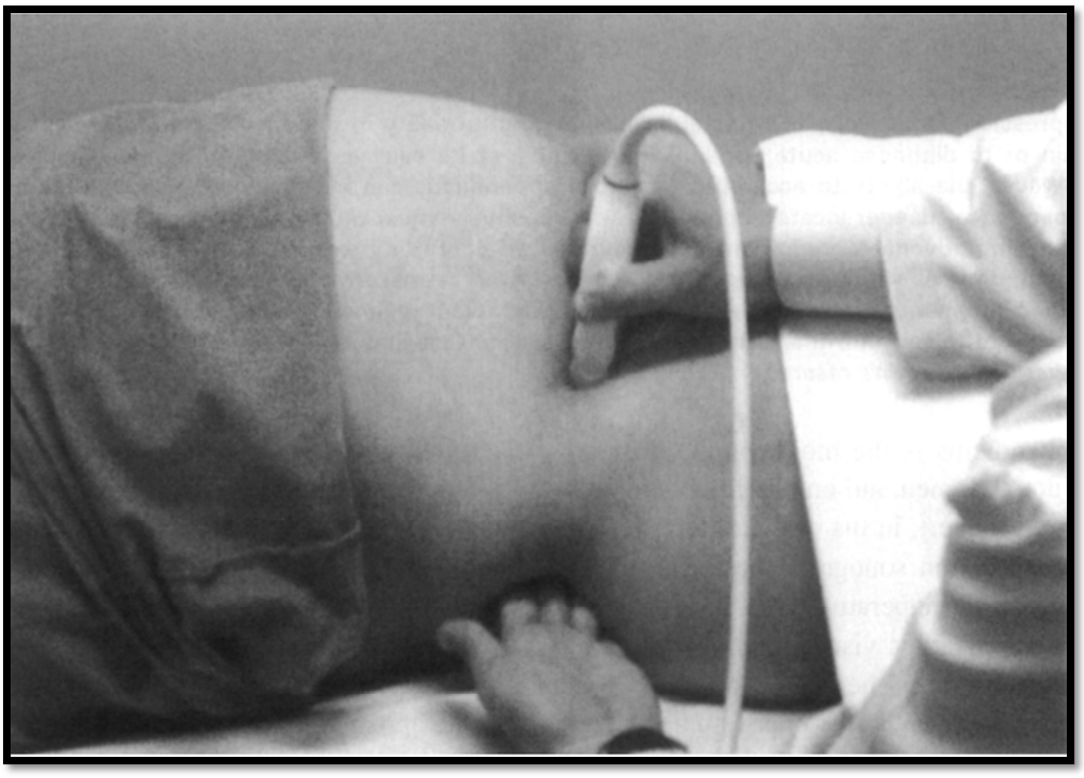


Fig 4 Ultrasonography of right iliac fossa to visualise appendix

A cutoff point of 6 mm or more is used in US criterion for accurate measurement of outer appendicular diameter, establishing acute appendicitis. "Pseudothickening" or normal appendix with an outer diameter of 6 mm or greater, often caused by lymphoid hyperplasia or inadequate compression. CT findings include wall thickening & enhancement, and peri appendicular fat stranding, as well as appendicolith, phlegmon, abscess, extra luminal gas, adenopathy, peri appendiceal collections, or thickening of the adjacent bowel wall. [17]

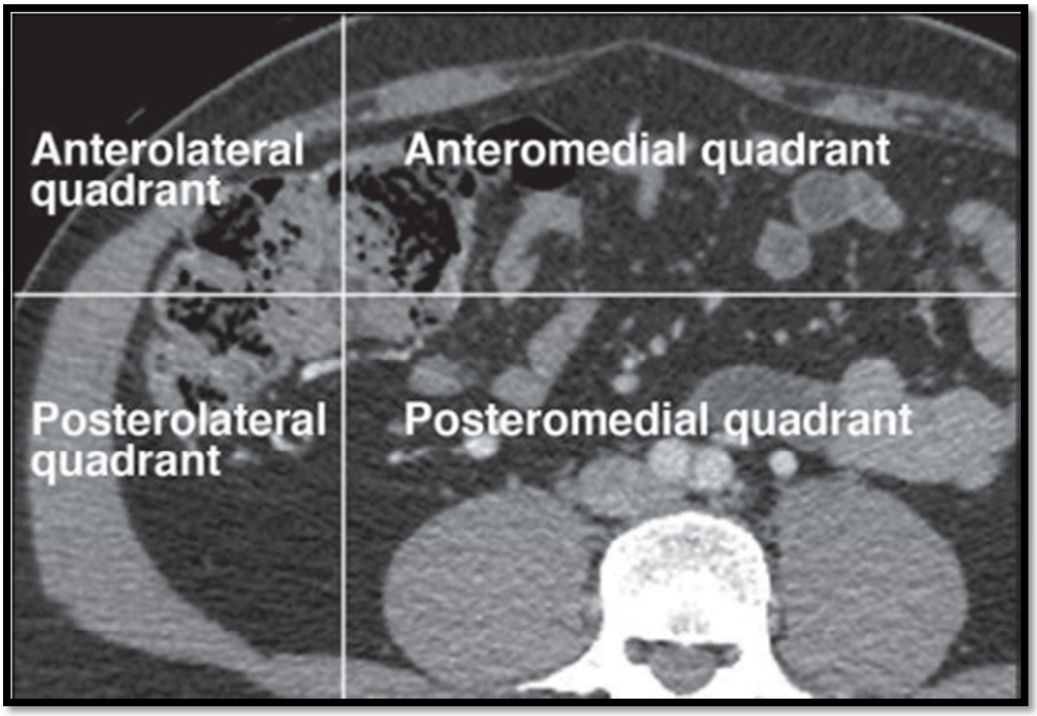


Fig 5 Axial view of appendix on CT

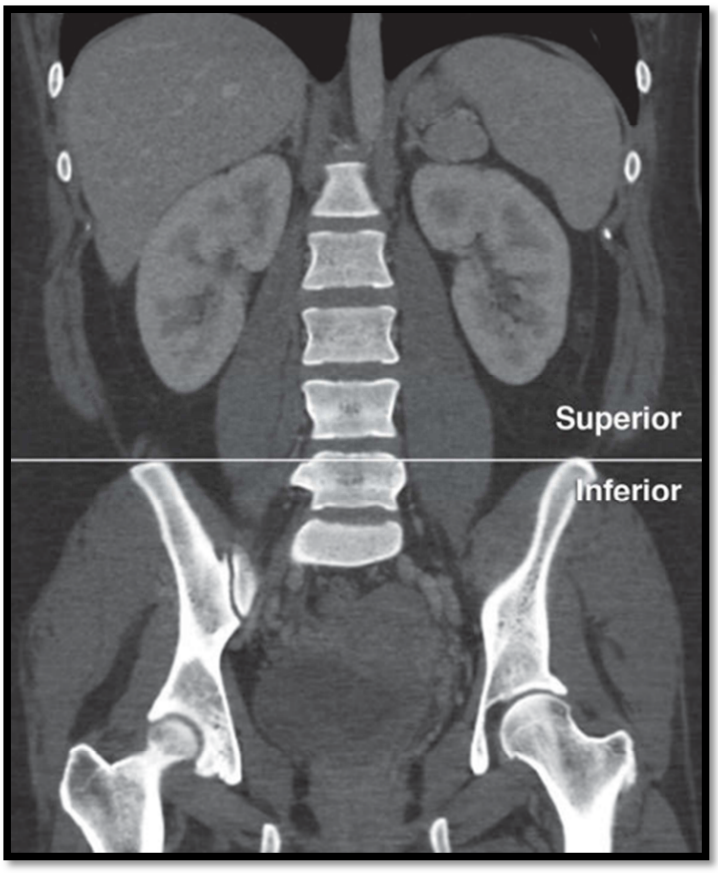


Fig 6 Coronal view of appendix on CT

When an acutely inflamed appendix perforates and pus is evacuated into the periappendiceal or remote area, the appendix may display a normal value of diameter. Careful tracing of the tip of appendix and surrounding regions is required. Clearly identifying a vermiform appendix as normal could be the most crucial factor in ruling out acute appendicitis and deciding whether surgery is necessary. After ruling out acute appendicitis, the radiologist has to focus on other conditions in the right inferior quadrant that mimic appendicitis, like ureteral calculi, acute enterocolitis and mesenteric lymphadenitis, right colon diverticulum inflammation, and right segment omentum infarct. [14][15]

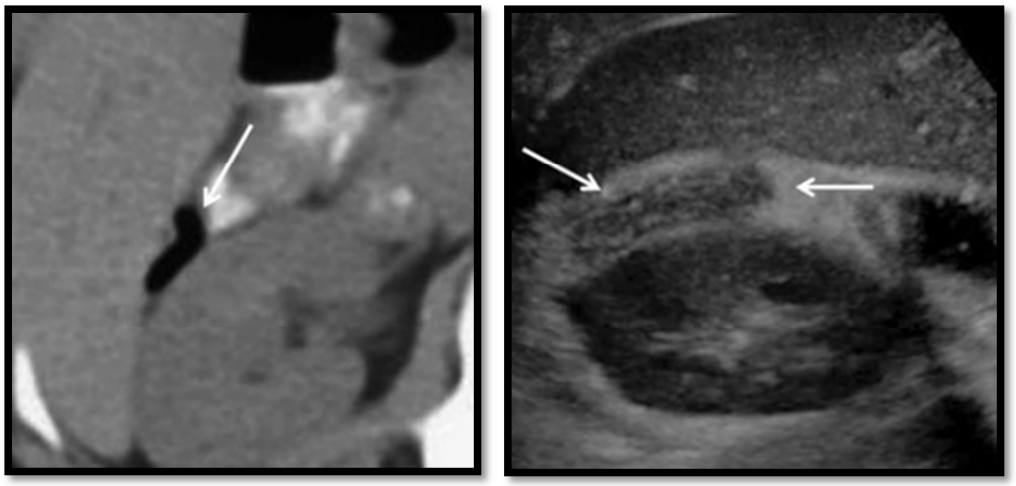


Fig 7 Unusual course of the appendix (arrows) in the upper abdomen into the hepatorenal fossa on CT and abdominal ultrasound

SURGICAL SIGNIFICANCE OF DIAMETER OF APPENDIX

A metanalysis of 130 studies involving 20,331 subjects found that the diameter of appendix was 7.95 mm. People without known appendicular pathology had smaller diameter than those diagnosed with acute appendicitis. No significant differences were found between paediatric and adult groups. Complicated cases of appendicitis were associated with increased outer diameters, and the same trend was when comparing perforated and non-perforated appendix. In acute appendicitis, the diameter measurement of the structure depended on the image technique used. Largest values were seen in CT, followed by ultrasonography and magnetic resonance imaging.

In a study by Deshmuk s, Et al, Internal diameter was analysed in five studies, with a pooled mean of 2.41 mm. Internal diameter was significantly large in mucocele compared to healthy subjects, but no significant size differences were found between inflamed and non-inflamed appendix. [16]

The outer diameter of the appendix on ultrasonography and hs-CRP levels in cases of complicated appendicitis are statistically correlated.[17] In a study that compared complicated and non-complicated appendix condition, the outer diameter was measured. According to reports, the diameter of the appendix was statistically significant and measured 6.9 milli meter (± 4.08 milli meter) in cases of non-complicated appendicitis and 7.6 milli meter (± 3.92 milli meter) in cases of complicated appendix.[18]

Fig 8 Axial and coronal CT demonstrated dilated fluid-filled appendix with extensive appendiceal inflammation

The appendicitis severity index (APSI) is determined by four CT findings and three clinical factors: diameter more or equal to 14 mm, presence of peri-appendicular fluid, extra luminal pockets of air, surrounding abscess, age more or equal to 52 years, body temperature ≥ 37.5°C, and duration of symptoms more than or equal to 48 hours. Complicated appendicitis was predicted with a PPV of 92% and NPV of 83%

if the score was ≥ 4. Adults with complex appendicitis can be accurately and simply predicted using APSI.[19]

Appendectomy is one of the most common surgical emergencies treated by surgeons. The most common type of appendectomy procedure is laparoscopic.

However, a challenging case of complicated appendicitis involving a mass, abscess, or perforation may force the operating surgeon to switch to open surgery. Difficult anatomy, dense bowel and omental adhesions, perforations near the base, widespread peritonitis, and the retro-caecal and sub-hepatic locations were the causes of the conversion. Due to all of these, the laparoscopic approach became difficult to follow, forcing the operating surgeon to switch to open surgery.[20]

SURGICAL CONSIDERATIONS

Appendectomy rates in the US have been reported to be 26 per 10,000 annually. In 1894, McBurney wrote about the gridiron incision used to remove the appendix. For a century, this was the main method of appendectomy; however, in 1980, Semm published the first description of the laparoscopic technique.

- ***Surgical Approach –***

  a) *Open Technique:* When performing an open appendicectomy, different incisions may be made based on the patient's clinical presentation and the surgeon that would be performing the procedure. The grid iron incision, also known as McBurney's incision, is an incision that is made perpendicular to a right spino-umbilical line with the centre of the incision lying at the McBurney's point. McArthur was the first person to describe this type of incision. Grid iron incisions were first described by McArthur. An incision

known as a Lanz incision is a transverse incision that is 2 centimetres below the umbilicus and is centred on the mid-clavicular-mid inguinal line. An expansion of the muscle-cutting gridiron incision, the Rutherford-Morrison incision may be found in the lateral part of the body. It's possible that the appendix may be located and delivered to the wound with only a finger inserted into the abdominal cavity. In the event that it is necessary, the anterior taenia coli of the cecum may be followed by gently holding the cecum and using it as a guide in order to locate the base of the appendix. In cases where the appendix is located behind the cecum, it is necessary to perform medial mobilisation of the cecum in order to gain access to the appendix. Following successful appendix mobilisation, the vascular pedicle is separated using clamps, and the ends are knotted. It is possible to carry out this procedure in a single step at the base of the appendix.

b) *Laparoscopic Technique:* Laparoscopy's use as a diagnostic tool, in particular for women of childbearing age, is the aspect of the procedure that provides the most benefit to the treatment of suspected appendicitis. In most cases, the surgeon will position himself on the left side of the patient, with the assistant on his right side. The anaesthesiologist and the equipment used for anaesthesia will be put at the head end of the patient, and the monitor will be positioned at the patient's feet. In most cases, the surgery will include the placement of three ports. Two of them are immovable, namely the umbilical and suprapubic incisions; the third incision may be made on either the left or right periumbilical area, and its exact location is very variable according on the patient's anatomical make-up. The appendix is retracted upwards while being held in an atraumatic grasper. This exposes the mesoappendix, which is then

split and ligated in order to skeletonize the appendix. Now the base of the appendix is either transected using a linear stapler or ligated with a suture ligature, and it is extracted out of the abdominal cavity using a laparoscopic pouch via an umbilical or suprapubic cannula.

MATERIALS AND METHODS

One-year observational study to determine the size of appendix in patients undergoing laparoscopic appendectomy, conducted at J. N. Medical College KLE Dr. Prabhakar Kore Hospital and Medical Research Centre attached to KAHER. Study period was for one year from September 2022 to August 2023. With a sample size of 63 and universal sampling technique, all the patients undergoing surgery for acute appendix with laparoscopy were included in the study.

Inclusion Criteria:

- Willing to participate in the study
- Clinical diagnosis of acute appendicitis and undergoing appendectomy.
- More than 18 years and less than 70 years.

Exclusion Criteria:

- Patients undergoing surgery where appendectomy was part of another procedure.
- Patients who had undergone a previous abdominal surgery.
- Diabetic patients or patients with other co-morbidities.

Data collection procedure:

Patient demographic details, signs and symptoms along with detailed history was recorded. Initial radiological evaluation was done with ultrasonography in all patients. Further imaging was done with contrast enhanced CT in selected patients for further evaluation if required.

Patients underwent laparoscopic appendicectomy and the decision to convert to open surgery was left to surgeon's choice.

Data processing and analysis/statistical analysis:

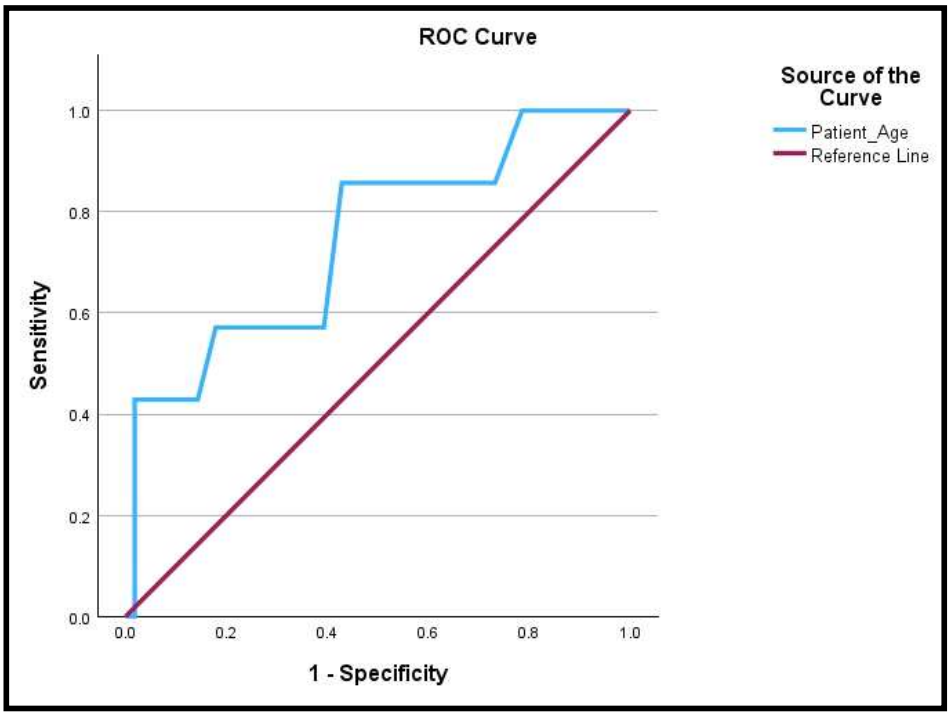
The data collected will undergo a statistical test called analysis of variance (ANOVA) to evaluate the significance of the independent variables in predicting the performance indicator with the help of 'p test'.

The graph of sensitivity and specificity (Receiver operating curve) will be plotted in Microsoft Excel to find the threshold value to determine when the procedure is converted to open appendectomy.

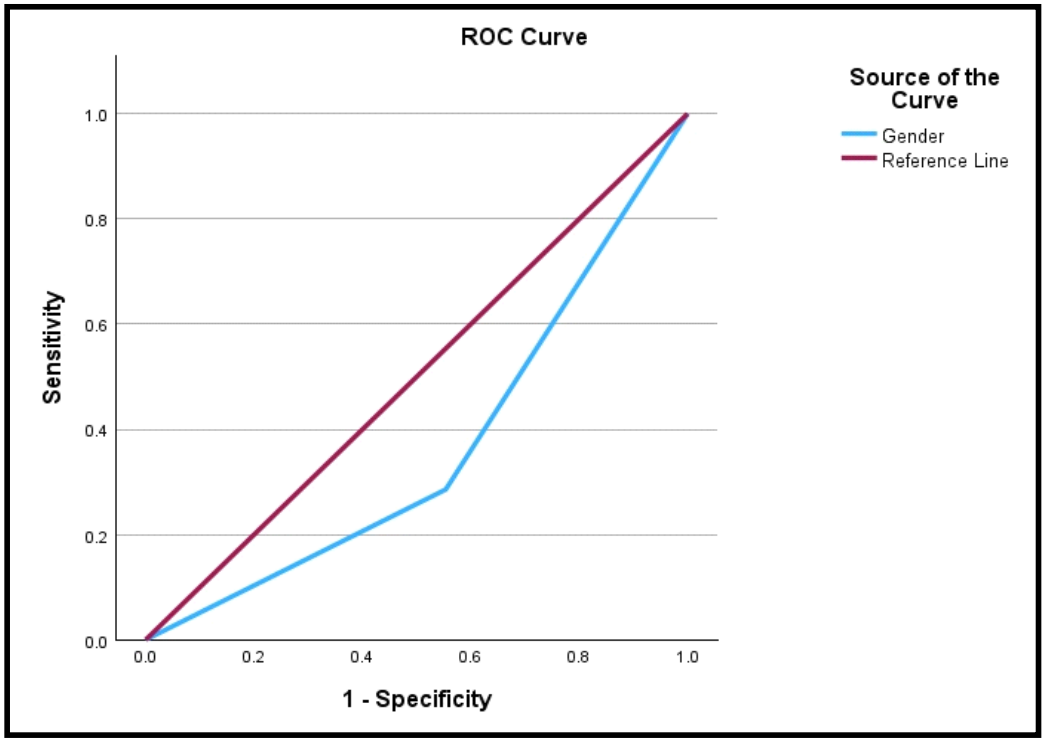
RESULTS

The Receiver operating characteristic curve was generated for converted to open cases for all the predictors such as age, gender, imaging modality and appendix diameter in SPSS statistical software.

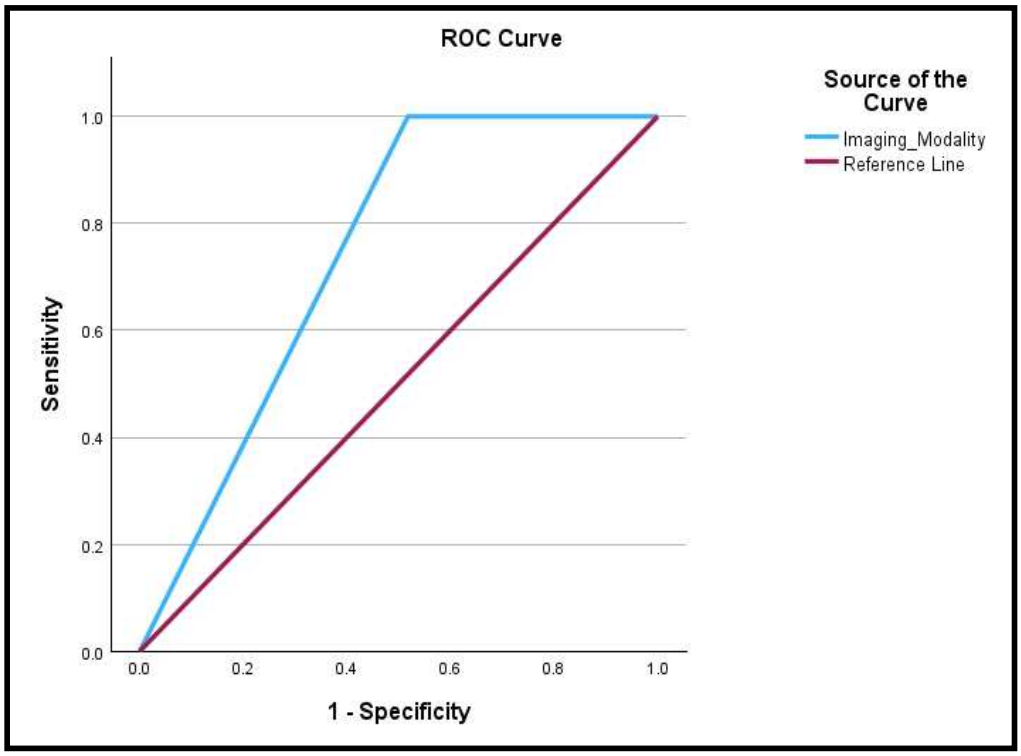
The receiver operating characteristic curve for all the predictors are shown in the Figs. 1-4.



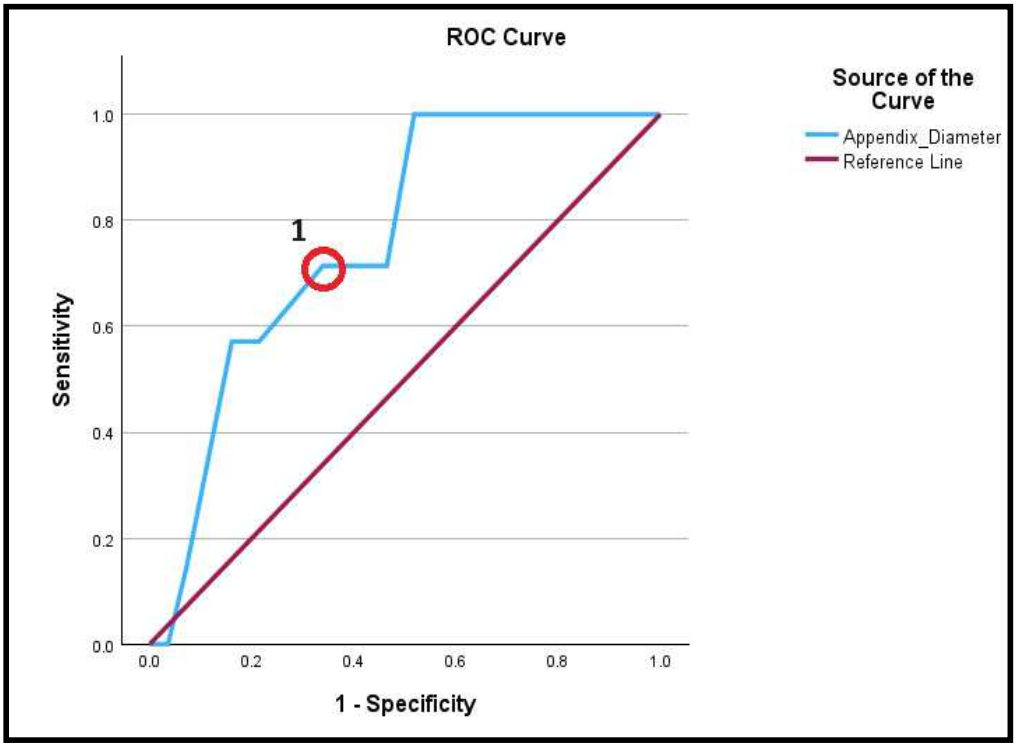
Graph 1 ROC curve for patient age as a predictor of converted to open cases



Graph 2 ROC curve for patient gender as a predictor of converted to open cases



Graph 3 ROC curve for Imaging Technique as a predictor of converted to open cases



Graph 4 ROC curve for Appendix diameter as a predictor of converted to open cases

In order to find the specificity and sensitivity for appendix diameter, point 1 in Fig.4 being very close to the top most left corner is considered and sensitivity, 1-specificity are calculated for point 1. From Fig.4 it is quite evident that the sensitivity is 0.725 and 1-specificity is 0.325 at point 1 for the case of appendix diameter as a predictor of converted to open cases. The values of sensitivity and 1-specificity, as given in Fig.5, nearest to a sensitivity value of 0.725 and 1-specificity value of 0.325 are selected i.e. 0.714 and 0.339 and the corresponding appendix diameter value is 8.95mm. So, a value of 8.95 mm is considered as a cut-off value for appendix diameter in converted to open cases.

Table 2: Co-ordinates of ROC curve for Appendix diameter

Coordinates of the ROC Curve

Test Result Variable(s): Appendix_Diameter

Positive if Greater Than or Equal To[a]	Sensitivity	1 - Specificity
5.3000	1.000	1.000
6.6500	1.000	.982
7.2500	1.000	.857
7.6500	1.000	.839
7.9000	1.000	.768
8.2000	1.000	.643
8.4500	1.000	.607
8.5500	1.000	.518
8.6500	.714	.464
8.7500	.714	.446
8.8500	.714	.393
8.9500	.714	.339
9.0500	.571	.214
9.1500	.571	.161
9.3000	.143	.071
9.5000	.000	.036
9.6500	.000	.018
10.7000	.000	.000

Table 3: Diameter group identified on CT and USG

Diameter	CT	USG
Less than 5mm	0	0
5-7mm	0	1
7.1-9mm	16	22
More than 9mm	20	4

Table 4 Age group for cases converted to open beyond cut off diameter

Age group	Gender		Diameter above cut-off	Converted to open (Diameter)	Reason for conversion
	Male	Female			
18-28	15	4	8	1 (9.2mm)	Anatomy not clear
29-45	9	11	10	1 (9mm)	Retrocecal adherent appendix
46-65	8	11	9	1 (9.2mm)	Abscess
66 and above	1	4	3	2 (9.4mm, 9.2mm)	Perforated at the base

DISCUSSION

Surgical management of acute appendix is the best option and laparoscopic method is the preferred choice for all the surgeons. Open procedure was the only option till laparoscopic techniques became available. While laparoscopic procedure holds far greater benefits than open surgery, in cases where a laparoscopic approach has been converted to open surgery, the patient has suffered greater morbidity along with increased hospital expenses and prolonged stay in the hospital. Not to mention about the increased intra-op time and effects of prolonged anaesthesia like toxicity to anaesthetic agents, respiratory depression, hypoxia due to impaired gas exchange, venous thromboembolism, prolongs stay by likely need of continued mechanical ventilation and difficult extubation, invariable damage to organs like kidney, heart and liver.

Although the diagnosis of acute appendix is mostly clinical, availability of imaging techniques helps the operating surgeon make better planning which can aid his intra-op management. Diagnosis with imaging modality include many factors, but diameter of appendix remains one of the significant factors with literature supporting a diameter >6mm for the diagnosis of acute appendix. Other factors include edema, echogenicity, vascular enhancement and local pathologies. Diameter can be measured on USG, CT and MRI, however contrast enhanced CT gives far more better findings compared to other modalities.

While the surgical skills dictate the course of the procedure and its outcome, considering that the operating surgeons have the minimal skills required for a laparoscopic appendicectomy there will be instances such as in cases with mass/abscess formation, perforated, adherent, uncommon position of appendix which

will warrant laparoscopic procedure to be abandoned and proceed to convert it into open procedure. But such conversions don't happen in all the complicated appendix cases.

Although laparoscopic approach is proven to be superior but it may not benefit the patient is certain scenarios. In some cases, direct approach with open surgery will benefit the patient.

Few pre-op parameters can be considered in aiding the decision-making process of whether or not to directly proceed with open procedure instead of approaching with laparoscope. This will help overcome disadvantages of conversion to open surgery. Decision to convert and type of incision for open surgery is solely surgeons' choice. Appendix diameter and surgical outcome have been linked in previous studies.

Prekh Et al. in their study with 80 patients concluded that mean appendicular diameter was significantly higher (≥7.95mm) among the patients with complicated appendicitis.[17]

Harsha Et al. conducted a study with 160 patients which showed radiological evidence of complicated appendicitis, TLC and serum bilirubin as predictors for risk of conversion to open surgery. [20]

Akturk Et al. in their study determined that appendicular diameter of 14mm as a predictor for conversion to open procedure in laparoscopic appendectomy.[26]

In a meta-analysis conducted by Kacerzyk Et al. out of 130 studies included 20,331 subjects, it reported measurement of outer diameter of 7.95mm (95%CI; 7.802-8.11) in case of complicated appendicitis.. [15]

In a study conducted by Martin Et al. in American Society of emergency radiology, the CT image of 134 patients were reviewed, the average appendicular diameter for conversion in complicated appendicitis was 11mm. [28]

In a study conducted by Bettina Et al. 26 of 234 patients required conversion to open for which the appendiceal diameter was significant factor (12.9mm ± 3.9) [27]

In a study conducted by Anubhav Et al. in India population it was found that appendicular diameter is a single predictor for conversion to open appendectomy. [29]

In this observational study, attempt is made to find a cut off value of pre-op diameter of the appendix, beyond which there is a high possibility that the surgery maybe to converted to open if began with laparoscopic approach. Previous research compared blood parameters, local complications and past surgical history with few studies suggesting that the appendix diameter having some correlation with the outcome of the surgery.

The Receiver operating characteristic curve was generated for converted to open cases for all the predictors such as age, gender, imaging modality and appendix diameter in SPSS statistical software.

In the present study the cut off value of diameter greater than 8.95mm is likely to be converted to open surgery. This can be considered as one of the parameters which will the aid the operating surgeon to make a well-informed decision pre-operatively and counsel the patient accordingly.

CONCLUSION

In our study the cut off value of diameter is found to be 8.95mm which suggests that there is high probability of the procedure being converted to open. The most common reason for conversion in our study is perforation. Technical expertise of the operating surgeon plays an important factor. Pre-op diameter of appendix when combined with other blood parameters and local pathological findings will form a better criterion for predicting such conversions. Further studies are required to analyse more parameters and arrive at an accurate predictor.

SUMMARY

Surgeons prefer to use laparoscopic techniques for the intricate surgical management of acute appendix problems. On the other hand, patients may experience higher morbidity, higher hospital costs, and longer hospital stays if a laparoscopic procedure is changed to an open procedure. Imaging methods can help with intraoperative management; one important consideration is the appendix's diameter. Diameter can be measured with MRI, CT, and USG scans; better results are obtained with contrast-enhanced CT scans.

The procedure's path and result are determined by the surgeon's skills, but in certain instances, the laparoscopic approach may be forsaken in favour of an open procedure to remove the appendix.

The goal of this observational study was to determine the appendix's pre-op diameter cut-off value which is 8.95mm, above which there is a significant chance that, should the laparoscopic approach be used, the surgery may have to be changed to an open procedure.

Appendix diameter and surgical outcome have been linked in previous studies. For converted cases, the Receiver Operating Character Curve was created, cut off value of diameter was established with the help of *p*-value(8.95mm), enabling surgeons to make knowledgeable preoperative decisions that are advantageous to the patient as well as the surgeon.

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ANNEXURE I- CONSENT

KAHERs JNMC BELAGAVI

INFORMED CONSENT FORM

"EVALUATION OF PRE-OPERATIVE OUTER DIAMETER OF APPENDIX IN PREDICTING CONVERSION TO OPEN SURGERY IN LAPAROSCOPIC APPENDECTOMY- ONE YEAR OBSERVATIONAL STUDY, AT KAHER'S DR. PRABHAKAR KORE CHARITABLE HOSPITAL AND MEDICAL RESEARCH CENTRE, BELAGAVI-590010.**"**

Name of Student/Principal Investigator: DR.

Name of Guide/Co Investigators: DR.

Objective: To evaluate pre-operative outer diameter of appendix in predicting conversion to open surgery in laparoscopic appendectomy.

Introduction: Acute appendicitis is most common emergency that presents to causality, with complains of acute pain abdomen, which requires quick diagnosis and intervention. In complicated appendectomies, conversion to open surgery may be required to perform a safe appendectomy and to avoid any surgical complications. It would be ideal to have pre-operative predictors which will help us identify patients with high risk of requiring open surgery. This would help in enhanced communication between the surgeon and the patient with respect to the outcome and prognosis. It will be helpful for the surgeons to make a choice of the surgical approach and avoiding laparoscopic surgery in cases where it is unlikely to be successful. Therefore, this study aims to identify such factors which will aid this decision making for the operating surgeon.

Explanation of procedure: Once you have signed the informed consent, necessary personal information and detailed medical history will be taken by the investigator. After this you'll be subjected to imaging (USG/CT) to determine the appendicular diameter and the surgical procedure carried out i.e., laparoscopic appendectomy.

Withdrawal from participation in the study: Participation in this study is voluntary. You will be free to decide whether to participate in this study or continue participation once enrolled. In case you decide to withdraw your participation, you are free to do so. However, please convey the decision to the principal investigator.

Possible benefits from participating in the study: You will/will not have nor get any benefits by participating in this study. The data gathered will help the population at large.

Possible risks from participating in the study: There are no risks involved in participating in this study.

Privacy and confidentiality: The information collected from you will be coded, to prevent any person from identifying you. Your identity will never be revealed. The data collected from you will be kept confidential and only processed or aggregated data will be used for publication.

Financial incentives: You will not receive any payment for participating in this study.

Authorization for publication of aggregated data: Results obtained after processing of the aggregated data will be published for scientific purposes and or presented to scientific groups. However, your identity will never be revealed.

Questions: In case of any questions with regard to this study, you are free to contact: Dr. Harsha Hegde, Chairperson, Ethical committee of JNMC, 0831-2473777 Extension 4052.

Legal rights: By signing this consent form, we are not waving any of your legal rights.

CONSENT STATEMENT

I am making a voluntary decision to participate in the study "EVALUATION OF PRE-OPERATIVE OUTER DIAMETER OF APPENDIX IN PREDICTING CONVERSION TO OPEN SURGERY IN LAPAROSCOPIC APPENDECTOMY-ONE YEAR OBSERVATIONAL STUDY, AT KAHER'S DR. PRABHAKAR KORE CHARITABLE HOSPITAL AND MEDICAL RESEARCH CENTRE, BELAGAVI-590010". My signature below indicates that I have decided to participate and I have read the information provided above or the information provided above has been read to me in the language that I understand best. I was given the opportunity to ask questions and that they have been answered to my satisfaction.

Name of the participant:

Signature or left thumb impression of the participant:

Name of the witness:

Signature or left thumb impression of the witness:

Name of the investigator:

Signature of the investigator:

ANNEXURE II- PROFORMA

I.P. No

1. Name of the Patient:

2. Age:

3. Gender: 1. Male 2. Female

4. DOA:

5. DOD:

6. Date of Interview:

7: Address:

8: Phone:

9: Occupation:

Unemployed

Unskilled

Semi-skilled

Skilled

Professional

10: Education:

Illiterate

Primary (1^{st}-7^{th} std)

High school (8^{th}-10^{th} std)

Intermediate

Degree and above

11: Socio-economic status:

Low

Middle

High

SCREENING

12: H/O Appendicitis:

YES

NO

13: H/O other illness:

YES

NO

14: If yes mentioned

15: Applicant is willing to give consent

YES

N0

FINAL RESULT

Ineligible

Eligible but refused

Eligible and participating

Data collection instrument:

1. Duration of Pain –

2. Location of pain-

    Right lower quadrant

    Left lower quadrant

    Right upper quadrant

    Left upper quadrant

3. Mode of onset-

    Spontaneous

    Insidious

4. Associated symptoms-

    Fever

    Pain

    Vomiting

    Nausea

5. Medical history:

    Diabetes mellitus

    Hypertension

    Asthma

    CVD

1. Examination:

1.

Height	Weight	BMI

2.

Pulse rate	Blood pressure	Temperature	Respiratory Rate

3. Per abdomen examination

1) Point of tenderness- Right iliac fossa

- YES
- NO

2) Rebound Tenderness

- YES
- NO

3) Guarding

- YES
- NO

4) Rigidity

- YES
- NO

5) Bowel Sounds

- YES
- NO

Diameter of the appendix on imaging (USG/CT)

- USG
- CT

Underwent laparoscopic appendectomy

- YES
- NO

Laparoscopic converted to open appendectomy?

- YES
- NO

ANNEXURE III - PHOTOGRAPHS

Perforated appendix specimen

ANNEXURE IV – MASTER CHART

S. No	IP No.	Age	Sex	Imaging Modality	Diameter of appendix	Converted to open
1	10048490	28	MALE	CT	8MM	NO
2	10048414	48	FEMALE	USG	8.7MM	NO
3	10043918	49	FEMALE	CT	7MM	NO
4	1174315	48	MALE	USG	7MM	NO
5	1171782	65	MALE	USG	8.5MM	NO
6	1169845	49	FEMALE	CT	8.8MM	NO
7	1166503	52	FEMALE	USG	7MM	NO
8	1162979	29	FEMALE	USG	7.8MM	NO
9	1171423	26	MALE	USG	8.4MM	NO
10	1162991	28	FEMALE	USG	8.5MM	NO
11	1198431	33	FEMALE	CT	7.5MM	NO
12	1127651	52	FEMALE	USG	7MM	NO
13	1201932	48	FEMALE	USG	6.3MM	NO
14	1125971	56	MALE	USG	7.8MM	NO
15	1139543	43	MALE	CT	9MM	YES
16	1143813	52	FEMALE	CT	9.2MM	YES
17	1126602	73	FEMALE	CT	8.6MM	YES
18	1125112	72	FEMALE	CT	9.4MM	YES
19	10046641	22	MALE	CT	7.8MM	NO
20	1160444	51	MALE	USG	8MM	NO
21	1161871	59	MALE	USG	8MM	NO
22	1161971	30	FEMALE	USG	9MM	NO

23	1163349	49	MALE	CT	8.9MM	NO
24	1000095	19	FEMALE	USG	9.2MM	NO
25	10003039	34	MALE	USG	8.9MM	NO
26	10007085	32	MALE	CT	8.6MM	NO
27	10007855	51	FEMALE	CT	9MM	NO
28	10012906	19	MALE	USG	8.5MM	NO
29	10016467	43	FEMALE	USG	8MM	NO
30	10023087	69	FEMALE	CT	9.1MM	NO
31	10026274	55	FEMALE	CT	8.8MM	NO
32	1000022	38	MALE	CT	8.6MM	NO
33	1196832	19	MALE	USG	8.5MM	NO
34	1200431	45	FEMALE	CT	7MM	NO
35	1173486	36	MALE	USG	8.6MM	NO
36	1172462	54	MALE	CT	8MM	NO
37	1198376	28	FEMALE	CT	7.8MM	NO
38	1183220	81	MALE	USG	8MM	NO
39	10033120	22	MALE	CT	8.9MM	NO
40	10036826	22	MALE	USG	9MM	NO
41	10036742	26	FEMALE	USG	8MM	NO
42	1174112	27	MALE	USG	7MM	NO
43	1176109	35	FEMALE	USG	8.5MM	NO
44	1176386	31	MALE	USG	8.4MM	NO
45	1183554	20	MALE	USG	7MM	NO
46	1176234	27	MALE	CT	8.8MM	NO

47	1166241	42	FEMALE	CT	8.6MM	YES
48	1168235	27	MALE	CT	9.2MM	YES
49	1166895	35	FEMALE	CT	9MM	NO
50	1170238	24	MALE	CT	9.4MM	NO
51	1160720	21	MALE	CT	9.1MM	NO
52	1162198	27	MALE	CT	9.2MM	NO
53	1163467	35	FEMALE	CT	9.2MM	NO
54	10003357	38	MALE	CT	9.7MM	NO
55	10006962	34	MALE	CT	9.6MM	NO
56	10019860	25	MALE	CT	9MM	NO
57	10022850	37	MALE	CT	9.2MM	NO
58	10027952	54	MALE	CT	9MM	NO
59	1190099	49	FEMALE	USG	9MM	NO
60	1183581	46	FEMALE	CT	9.1MM	NO
61	10032449	70	FEMALE	CT	9.2MM	YES
62	10035565	45	FEMALE	CT	9.2MM	NO
63	1177627	42	FEMALE	CT	9.4MM	NO