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Original Article

Anatomy Section

Luminal and Extraluminal Factors in Normal and Pathological Appendix- A Cadaveric Study from Central Kerala, India

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ABSTRACT

Introduction: Appendicitis is the most common clinical entity among the acute abdominal emergencies. Variations in the position of appendix along with degree of inflammation makes the clinical presentation of the condition notoriously inconsistent. Anatomical knowledge about the organ is thereby mandatory for the clinical assessment and to make a confident diagnosis. Obstructive causes have been found to be responsible in 50-80% cases of acute appendicitis. The way in which the inflammatory process proceeds, still remains a topic of debate.

Aim: To study the luminal and extraluminal factors in both normal and pathological appendices.

Materials and Methods: This was a cross-sectional descriptive study on gross morphological parameters like frequency of various positions, blood supply of appendix, length of appendix and mesoappendix, gross luminal content conducted on 50 normal and 53 pathological appendices collected from the Departments of Forensic Medicine, Anatomy and Pathology in the Government Medical College, Kottayam, Kerala, India, for a period of one year from April 2013-March 2014. Data entered in the Excel sheet was further analysed using the Statistical Package for the Social Sciences (SPSS) software. Continuous variables were summarised as mean and Standard Deviation (SD) and the significance between their mean variables were analysed using t-test.

Results: The most common age group presenting with appendicitis was 15-30 years with male incidence more than female. Appendices were supplied by single artery in 64% and by dual arteries in 36% samples. The average length of normal appendix was 7.8±2.33 cm and pathological appendix was 6.05±1.83 cm. Total 34 (77%) of normal appendices and 9 (81.81%) of pathological appendices showed shortening in length of mesoappendix from the tip of appendix. Common positions in normal and pathological appendices were retrocaecal and pelvic, respectively. The most common complication presented in this study was perforation (n=7). Appendices were fixed in 16 (32%) of normal and 12 (22.6%) of pathological appendices. Fixity and complications were commonly associated with retrocaecal position.

Conclusion: Appendicitis was more common among the younger age groups. The positions of appendix had no role in initiating the appendicitis. But fixity in particular position played an important role in late presentation thereby favouring complications.

Keywords: Appendicitis, Appendicular arteries, Mesoappendix, Retrocaecal appendix

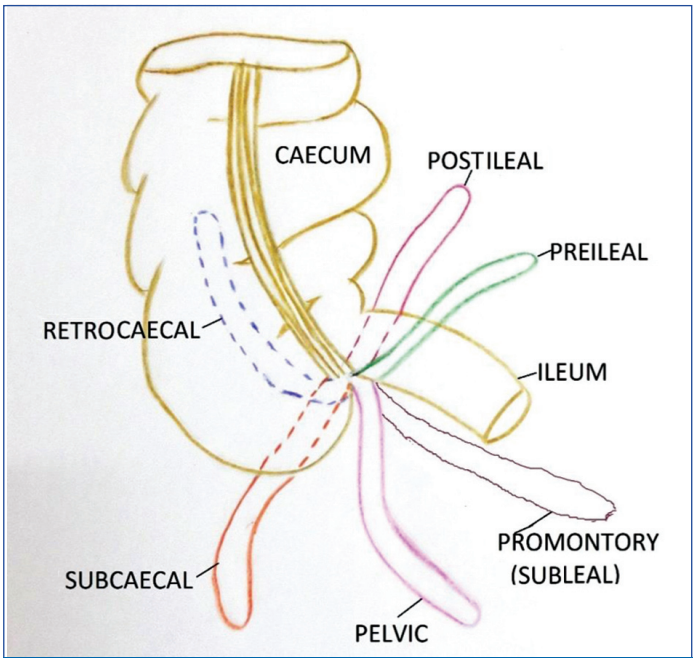
INTRODUCTION

The term vermiform appendix meaning 'worm like appendage at the end' was coined by Verhgen in 1710 [1]. Vermiform appendix is a narrow worm like tubular diverticulum which arises from the posteromedial wall of caecum about 2 cm below the ileocaecal junction and is suspended by a fold of double layered peritoneum called as the mesoappendix [2]. The length of the appendix varies between 2 cm and 20 cm, average length being 9 cm. It is relatively longer in young age and may atrophy and shorten after mid-adult life [2-4]. The length of appendix is considered as a primary factor in torsion of appendix [5].

The mesoappendix carries the blood supply to the organ and is also essential for its mobility [6]. A window could be created in mesoappendix, which acts as a path for clamping the stump of appendix during appendicectomy [7].

Sir Fredric Treaves (1885) described the various positions of the appendix [8], making the vermiform appendix as pointer and caecum as the dial of the clock as shown in [Table/Fig-1]. The most common position studied being retrocaecal (60%), followed by pelvic (30%), sub caecal and splenic (preileal and postileal) being 1-2% and the midinguinal is the rarest among all [9]. According to the previous literature reported, among above mentioned positions retrocaecal position was found to be less prone to inflammation [10].

The appendix is supplied by appendicular artery, which is derived directly from the ileocolic branch of superior mesenteric artery or the caecal (anterior and posterior caecal) or ileal branches of ileocolic artery [11]. The appendicular artery is an end artery that lies on the wall of the appendix and hence they may be prone to



[Table/Fig-1]: Various positions of vermiform appendix in relation to ileum and caecum.

thrombosis when it is inflammed. The accessory artery, if present, arises from the closely related arteries and has to be ligated during appendicectomy, the thrombosis of which, in acute appendicitis may lead to gangrene and subsequent perforation [12]. Perforation is prone to occur at the point where mesoappendix ceases, and gangrene may affect the free tip of the appendix, where no mesentery is seen [13]. As quoted above, so many studies were done to study the individual parameters of vermiform appendix, but none of them stated the possibility of all the anatomical factors in causation of appendicitis and its complications. As the obstructive cause for appendicitis and its related complications constituted about 50 to 80%, the condition never arose de-novo, except as a consequence of the interplay of factors that involve either its wall, length, diameter, position in abdomen or its blood supply [14].

Thus, the primary aim was to study the luminal and extraluminal factors of the organ in both normal and pathological appendices. Secondary aim was to find the association between the studied parameters in normal and pathological specimens, to understand the role of anatomical factors in initiation of appendicitis and its influence in progression to complication associated with it.

MATERIALS AND METHODS

This cross-sectional descriptive study was conducted on 50 normal and 53 pathological appendices collected from the Departments of Forensic Medicine, Anatomy and Pathology of Government Medical College, Kottayam, Kerala, India, for a period of one year from April 2013 to March 2014, after getting ethical clearance from Institutional Review Board [IEC/IRB No: 3/2013].

Inclusion criteria: Specimens which showed signs of inflammation like swelling and redness, external surface with blackish appearance and perforations were taken under pathological appendix and obtained from The Department of Pathology. Specimens without the above mentioned signs, with normal morphology was taken as normal appendix, which were obtained from cadavers of Anatomy Department and from the autopsy specimens of Forensic Department.

Exclusion criteria: Pathological appendix other than appendicitis like carcinoids, non-carcinoid tumours, adenocarcinoma and mucocele were excluded.

Sample size calculation: Minimum sample size calculated were 18 normal and 18 pathological appendices based on the mean and SD from the previous study [15]. With the feasibility of the required specimens in this study area, sample of 50 in normal and 53 in pathological were included, to make the result more valid and precise.

Study Procedure

Pretexted semistructured proforma was used to collect data which included variables like: Socio-demographic factors (Age, Sex), gross morphological factors: Extraluminal factors like various positions, length of appendix, length of mesoappendix, blood supply, external surface appearance to rule out the pathology. Luminal factors included the luminal content.

For normal appendix specimens: Upon opening the abdominal cavity, dissection was carried out in layers to reach the caecum and appendix. The position, fixity and relation of appendix to the neighboring abdominal contents were carefully noted in situ. Superior mesenteric artery was then dissected carefully to trace the blood supply of the organ. Once the arterial supply was studied, appendices were removed at Ileocaecal junction and examined for their luminal content. The length of appendix, length of mesoappendix were then measured using a measuring scale.

For pathological specimens: Appendicectomy done specimens for appendicitis collected from Pathology Department were traced back to the pre-operative notes in the relevant case sheets of the patients in Surgery Department to note the specific position of the appendix in relation to the caecum and ileum mentioned by the surgeon. Also their clinical presentations, investigations done preoperatively and information about the appendix on table were noted down from the case sheet [16]. Pathological appendices collected were carefully examined for their external surface, cut section and luminal contents. The gross parameters like length of appendix and mesoappendix were measured. The results were analysed and correlated to find the influence of anatomical factors in appendicitis and its associated complications.

STATISTICAL ANALYSIS

The data were entered in MS Excel sheet and further analysed using SPSS software 16.0 version. Data was presented as mean and SD for continuous variables and as percentages for categorical variables. Unpaired t-test was done to compare the means of two groups and Analysis of Variance (ANOVA) for more than two groups. Chi-square test was done to find out the association between categorical variables. A p-value less than 0.05 was considered significant.

RESULTS

For the convenience of description, the cases were classified into four different age groups (<15 years,15-30 years, 31-45 years and >45 years) in both normal and pathological appendices.

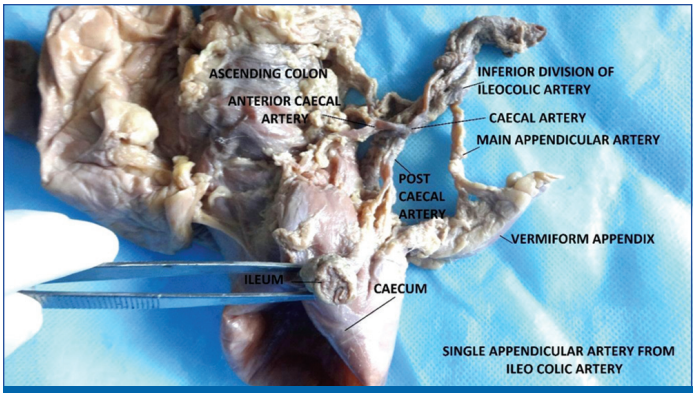
Age and sex distribution: Collected specimens of normal and pathological appendices were more in the age group of 15 to 30 years. The numbers were 18 (36%) and 26 (49.1%) respectively. Male 39 (78%) to female 11 (22%) ratio in normal specimens was 3.5:1. Among the appendicitis patients, majority were males 34 (64.15%) and remaining were females 19 (35.8%), with the ratio of 1.8:1. The mean age of patients with appendicitis was 21 years (SD-11.5).

Arterial supply: The arterial supply of the organ and its relation with age was studied [Table/Fig-2]. The organ was supplied either by single or by dual arteries. The present study did not show any statistically significant association between the age groups (Chi-square-2.834, p=0.418) and the type of arterial supply studied. Among 32 specimens studied for single arterial supply, the main appendicular artery arose from the lower division of ileocolic [Table/Fig-3] in 21 (65.6%) specimens followed by posterior caecal artery in 8 (25%), ileal branch in 2 (6.2%) and anterior caecal in 1 (3.1%) specimen. In dual arterial supply, the tip was supplied by the main artery and accessory arteries supplying the body of appendix arose from the closely related arteries of ileocolic. The accessory artery arising from posterior caecal artery is called the artery of Dr. Seshachalam. Among 18 specimens studied for the dual arterial supply, 12 (66.7%) showed branches from inferior division of ileocolic artery (main appendicular artery) and posterior caecal artery (accessory artery) [Table/Fig-4] and rest 6 (33.3%) showed branches from both the anterior and posterior caecal arteries.

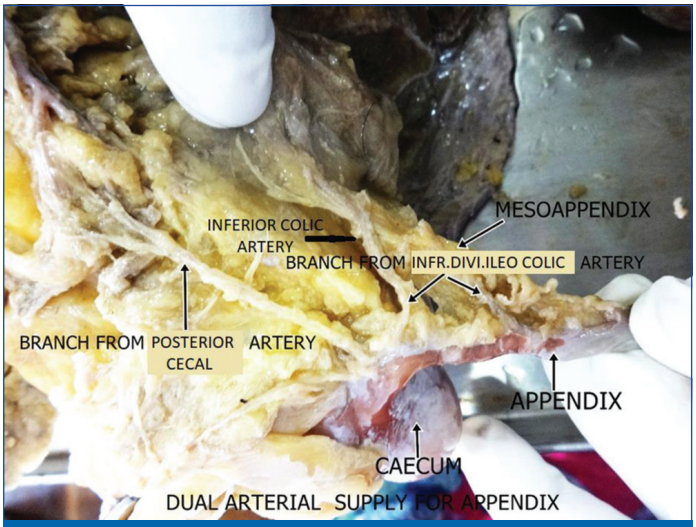
Length of the appendix: In the present study, average length of appendix for all age groups in normal and pathological appendices were 7.8±2.33 cm and 6.05±1.83 cm respectively. Regarding age wise change in the length of appendix, it gained length gradually up

Age group	Arterial supply		Total	p-value
	Single	Dual		
<15 years	4 (50%)	4 (50%)	8 (100%)	0.418
15-30 years	12 (66.7%)	6 (33.3%)	18 (100%)	
30-45 years	9 (81.8%)	2 (18.2%)	11 (100%)	
>45 years	7 (53.8%)	6 (46.2%)	13 (100%)	
Total	32 (64%)	18 (36%)	50 (100%)	

[Table/Fig-2]: Relationship of arterial supply with age categorised under four groups (N=50).

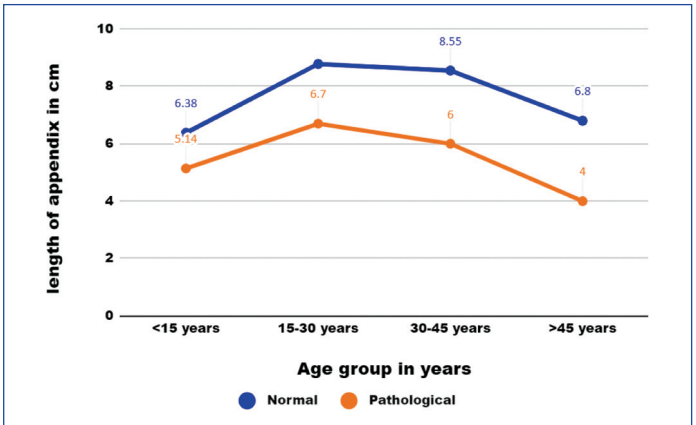


[Table/Fig-3]: Single arterial supply for the appendix from inferior division of ileocolic artery.



[Table/Fig-4]: Dual arterial supply for the appendix from the ileocolic and posterior caecal artery.

to adolescence period, and remained almost same up to 45 years of age. Thereafter, there was a gradual decrease in length of appendix in both normal and pathological appendices [Table/Fig-5]. This relation between the age and length of the appendix was found statistically significant (p=0.018 and 0.016) in both normal and pathological appendices, respectively. Length of appendix was found to be shorter in female (6.46±2.19 cm, 5.66±2.08 cm) than males (8.23±2.24 cm, 6.27±1.67 cm) in both normal and pathological appendices respectively.



[Table/Fig-5]: Age-wise change in the length of normal and pathological appendix.

Mesoappendix: The length of mesoappendix was measured in 44 normal and 11 cases of pathological appendices, out of which the average measurement was 6.66 cm (SD-2.036) and 5.5 cm (SD-2.34) respectively. Its measurement varied with the length of appendix. The age wise changes in length of mesoappendix [Table/Fig-6,7] was found similar to that of the length of appendix in both normal and pathological appendices. This relation between the age and length of the mesoappendix was not found statistically significant (ANOVA-1.720, p=0.178; ANOVA-0.297, p=0.827, respectively) in both normal and pathological appendices. Length of normal and pathological mesoappendix was found to be shorter in females (5.53±0.989 cm and 5.37±1.78 cm, respectively) than males (6.95±2.143 cm and 5.5±0.62 cm, respectively).

Age group	Number	Mean (cm)	SD	p-value
<15 years	8	5.38	0.648	0.178
15-30 years	17	6.95	2.188	
30-45 years	9	7.43	1.067	
>45 years	10	6.48	2.775	
Total	44	6.6	2.036	

[Table/Fig-6]: Age-wise change in length of mesoappendix in normal specimens.

Age group	Number	Mean (cm)	SD	p-value
<15 years	1	5.5	-	0.827
15-30 years	8	5.88	2.63	
30-45 years	1	4.5	-	
>45 years	1	3.5	-	
Total	11	5.5	2.34	

[Table/Fig-7]: Age-wise change in length of mesoappendix in pathological specimens.

Complications associated with mesoappendix: The length of normal mesoappendix extended to the tip of appendix in 10 (22.7%) samples belonging to the age group older than 45 years and fell short of the length of appendix in 34 (77%) among the age group less than 45 years. In pathological specimens, the mesoappendix fell short of the length of appendix in 9 (81.8%) among the age group of 15-45 years and reached the tip in 2 (18.2%) cases belonging to extremes of ages. Among the nine specimens presented with shortened mesoappendix in the age group 15-45 years, one perforation and three gangrenous appendicitis were found.

Position of appendix: The most common position found was retro-caecal in normal appendices [Table/Fig-8] and pelvic in pathological appendices [Table/Fig-9].

Fixity in normal and pathological appendices: Fixity was commonly associated with retro-caecal [Table/Fig-10] position in both normal and pathological appendices. This relation was not statistically significant in normal (Chi-square-7.76, p=0.10) but statistically significant only in pathological appendices (Chi-square-15.42, p=0.017).

Frequency of complications in various positions: Among the 53 pathological specimens studied, complications like perforation, peritonitis, and gangrene were found in 15 cases (28.3%), among which perforation was the most common complication presenting in seven cases (46.7%). Importance of complications in relation to position [Table/Fig-11] and age were studied.

Retrocaecal was the most common position that presented with complications in the present study. Among these complications, six were found in the age group less than 15 years, followed by five cases in the age group between 15-30 years, three cases were found in the age group between 31-45 years, and one case was found in age more than 45 years. More complications were found in the age group <45 years.

Gross luminal content: Faecal matter was commonly present in 22 (44%) of normal and 18 (34%) of pathological appendices followed by fecalith in 9 (18%) of normal appendices. In pathological appendices blood/haemorrhage was seen in 12 (22.64%) and fecalith in 7 (13.2%). Faecal matter and faecalith formed the obstructive contents of the lumen in most of the specimens. No contents were found in 19 (38%) normal and 10 (18.86%) in pathological appendices.

Age group (years)	Positions					Total
	Retrocaecal	Pelvic	Preileal	Postileal	Paracaecal	
<15	6 (75%)	2 (25%)	0 (0%)	0 (0%)	0 (0%)	8 (100%)
15-30	9 (50%)	6 (33.3%)	1 (5.6%)	0 (0%)	2 (11.1%)	18 (100%)
31-45	4 (36.4%)	4 (36.4%)	0 (0%)	2 (18.2%)	1 (9.1%)	11 (100%)
>45	5 (38.5%)	5 (38.5%)	0 (0%)	1 (7.7%)	2 (15.4%)	13 (100%)
Total	24 (48%)	17 (34%)	1 (2%)	3 (6%)	5 (10%)	50 (100%)

[Table/Fig-8]: Frequency distribution of various positions of normal appendix in different age groups.
The difference in positions of appendix among different age groups were not statistically significant (Chi-square-9.403, p=0.668)

Age group in years	Positions							Total
	Retrocaecal	Pelvic	Preileal	Postileal	Promontory	Paracaecal	Subhepatic	
<15	6 (33.3%)	4 (22.2%)	1 (5.6%)	1 (5.6%)	0	5 (27.8%)	1 (5.6%)	18 (100%)
15-30	6 (23.1%)	12 (46.2%)	2 (7.7%)	0	1 (3.8%)	5 (19.2%)	0	26 (100%)
31-45	3 (37.5%)	3 (37.5%)	1 (12.5%)	1 (12.5%)	0	0	0	8 (100%)
>45	0	0	0	0	1 (100%)	0	0	1 (100%)
Total	15 (28.30%)	19 (35.85%)	4 (7.54%)	2 (3.77%)	2 (3.77%)	10 (18.86%)	1 (1.88%)	53 (100%)

[Table/Fig-9]: Frequency distribution of various positions of pathological appendix in different age groups.
The difference in positions of appendix among different age groups was found statistically significant (Chi-square-36.318, p=0.007) only in pathological appendices

Position	Fixity in normal appendices			Fixity in pathological appendices		
	Fixed	Mobile	Total	Fixed	Mobile	Total
Retrocaecal	11 (45.8%)	13 (54.2%)	24 (100%)	8 (53.3%)	7 (46.7%)	15 (100%)
Pelvic	2 (11.76%)	15 (88.23%)	17 (100%)	1 (5.3%)	18 (94.7%)	19 (100%)
Preileal	1 (100%)	0	1 (100%)	0	4 (100%)	4 (100%)
Postileal	1 (33.33%)	2 (66.67%)	3 (100%)	1 (50%)	1 (50%)	2 (100%)
Promontory	0	0	0	1 (50%)	1 (50%)	2 (100%)
Paracaecal	1 (20%)	4 (80%)	5 (100%)	1 (10%)	9 (90%)	10 (100%)
Subhepatic	0	0	0	0	1 (100%)	1 (100%)
Total	16 (32%)	34 (68%)	50 (100%)	12 (22.6%)	41 (77.4%)	53 (100%)

[Table/Fig-10]: Comparison between the normal and pathological appendices regarding relation of fixity with position.

Positions	Perforation	Peritonitis	Gangrene formation	Total
Retrocolic	5 (55.6%)	2 (22.2%)	2 (22.2%)	9 (100%)
Preileal	1 (33.3%)	0	2 (66.7%)	3 (100%)
Promontory	0	0	1 (100%)	1 (100%)
Paracaecal	1 (50%)	1 (50%)	0	2 (100%)
Total	7 (46.7%)	3 (20%)	5 (33.3%)	15 (100%)

[Table/Fig-11]: Frequency of complications associated with various positions in appendicitis patients.

DISCUSSION

Appendicitis is one of the most common cause of acute abdomen. Marudanayagam R et al., found that the incidence of appendicitis was common (35.09%) in the second decade [17] reaching its peak in the teens and early 20s. This study favoured the findings of our study that the common age group presented with appendicitis was 15-30 years (49.1%) followed by the age group <15 years (34%). Marudhanayagam R et al., [17], reported that the incidence was more in male, the ratio being 1.5:1 which was similar to our study with the ratio of 1.8:1.

Neil RB et al., had mentioned the origin of appendicular artery from the inferior division of ileocolic artery [9]. In a study conducted by Hosmani V et al., [11] 46.15% showed the origin from the inferior division of ileocolic artery. In the present study, 32 samples showed the origin of main appendicular artery from the inferior division of inferior colic artery. Out of 18 specimens with the double arterial supply, the accessory arteries arose from the posterior caecal artery (artery of Dr. Scheshachalam) in 12 (24%) specimens which was found consistent with the study conducted by Hosmani V et al., [11] showing 21.87%. Extensive anastomosis between the arteries supplying the appendix were found in studies by Solanke TF and Simon AM et al [18,19]. However, no arterial anastomosis was found in the present study.

Bornali H and Rup Sekhar D, mentioned in their study that the length of normal appendix gradually increased up to 35 years with its propensity to decrease in later life [20]. The present study went in favour with this finding in both normal and pathological appendices. Longer appendix might form the primary cause for torsion in appendix [5] but no case of torsion was encountered to correlate its importance.

Banerjee A et al., in their study mentioned that the length of normal mesoappendix extended completely to the tip in only 16% and fell short of the length of appendix in 84% [21]. These results went hand in hand with our study in which 77% (age <45 years) of normal mesoappendix fell short of appendix and in 23% (age >45 years) it reached up to its tip.

Golalipour MJ et al., reported that the mesoappendix failed to reach the appendicular tip [22] in 65.8% of people with appendicitis, in which the people of age group 30-45 years presented with perforation. In this study, 81.8% of pathological mesoappendices fell short of the tip, out of which three cases presented with gangrene and one case with perforation among the age group 15-45 years. The mesoappendix thus plays an important role in vascularisation of appendix and its failure to reach the tip of appendix might favour complications like gangrene and perforation in appendicitis [6].

Mwachaka P et al., reported retrocaecal as the common position in his study on normal appendix [3] which was in favour with this study and Geethanjali HT and Subhash L, reported pelvic as the

common position in normal appendix [23]. Different positions might mimic different clinical conditions that lead to misdiagnosis varying from 10-33% [24].

Thyagaraj J studied the positions in normal and pathological appendices and concluded that positions had no role in altering the clinical course of appendicitis [25]. It had been stated that pelvic position has a pressure free surrounding thereby it may present early, whereas retrocaecal appendix may be kinked by loaded colon compromising their blood supply leading to presentations with complications [26]. Ghorbani A et al., also demonstrated that 75% of appendix in their study were anterior to caecum which favoured early diagnosis and short hospitalisation [27]. Thus, position per se does not play any role in initiating appendicitis but once initiated their presentation and its clinical course might get altered due to the position [25-27].

The importance of studying the relation of fixity and position of appendix in a study by Harsha WT mentioned that retrocaecal position of the appendix whether fixed by the inflammatory process or during the development when present clinically continued to be a challenging problem [28].

Herscu G et al., studied the rate of perforation with positions of appendix and found higher risk (60%) of perforation rate in retrocaecal position than the other positions. The hidden position might mislead to some other diagnosis leading to higher complication rates [29]. Thus this present study confirmed this finding, as retrocaecal position was commonly associated with complications. Kraemer M et al., and Gurleyik G and Gurleyik E, mentioned in their studies that complication rate was more in the older age groups than the younger age groups due to the delay in their presentation [30,31] but in this study more complications presented was in age group <30 years.

Ramadass MJ et al., studied 1357 appendicectomy done specimens and found the presence of fecalith in 13.7% (n=186) which was very close to our study which showed 13.2% (n=7) fecalith in appendicectomy done specimens. They quoted that there was a strong statistical association between the fecalith presence and acute appendicitis [32].

Limitation(s)

Length of mesoappendix was either not available or too short to measure in certain specimens of normal and pathological appendices. No case of torsion was encountered in the study to correlate the importance of length factor in torsion. The importance of mesoappendix in the possibility of gangrenous appendicitis among those it fell short of tip could not be correlated satisfactorily, as it was retrieved only in 11 pathological specimens. The relation between the anatomical factors and its role in complications could be made significant if done with large scale studies.

CONCLUSION(S)

Common age group presented with appendicitis was 15-30 years. Single appendicular arterial supply was more common than dual supply the knowledge of which is highly essential for the reconstructive surgeries. The most common position in normal appendices was retro colic and pelvic in pathological specimens. Position per se has no role in initiating appendicitis. Fixity in retro colic position can present late favouring complications. Morphology of mesoappendix carrying blood supply to the organ, in favour of complications like gangrene and perforation has to be evaluated in larger scale to generate significant results. The study explains the role of possible anatomical factors in initiation of appendicitis and its influence in associated complications.

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