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ORIGINAL ARTICLE

The role of the anatomy of the sigmoid colon in developing sigmoid volvulus: a cross-sectional study

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Abstract
Purpose The aim of this study was to determine the length of the sigmoid colon and sigmoid mesocolon in living subjects and fresh cadavers.
Methods The subjects for the study were consecutive 50 living subjects undergoing abdominal surgeries via midline incision and 50 fresh cadavers undergoing a medicolegal postmortem at Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun State, Nigeria.
Results The study showed that the mean length of the sigmoid colon in living subjects was 48.9 ± 1.3 cm (range 30.5–65 cm) while the mean length of the sigmoid colon in cadaver subjects was 50.1 ± 1.6 cm (range 34.5–67.8 cm) and this was not statistically significantly different. Two patterns of the shape of the sigmoid loop were identified: dolichomesocolic and brachymesocolic pattern. In about 80 % of subjects in both groups, dolichomesocolic-type was seen. The gender analysis showed that males had statistically significant longer sigmoid colon ($P = 0.040$). The dimension of sigmoid colon significantly increased with age of the patients in cadaver subjects and in both sexes ($P = 0.001$).
Conclusions The study concluded that the lengths of sigmoid colon are not different in living and cadaver subjects but are relatively longer than measurement from western countries. The lengths of sigmoid colon and mesocolon also increases with age and this may possibly be the anatomical basis for the frequent occurrence of sigmoid volvulus and failed colonoscopy among the older population in our environment.

Keywords Sigmoid colon · Sigmoid volvulus · Colonoscopy · Dimension · Nigeria

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Introduction

Sigmoid colon is part of the large bowel that is often associated with volvulus. These diseases are related to the anatomical peculiarities of sigmoid colon [4, 13]. The anatomical peculiarities include variation in length of the sigmoid colon as well as mobility and length of mesosigmoid. Racial variations of these anatomical peculiarities have been noted [5, 16]. This has been shown to be related to the variation in occurrence of sigmoid volvulus worldwide according to geography and population studies [11, 17, 18, 20, 21].

Sigmoid volvulus is relatively more common in developing countries such as Africa, Eastern Europe and India, where it represents 20–54 % of the cause of intestinal obstructions compared to 1–7 % in developed countries [9, 14]. Local studies from Nigeria have shown that sigmoid volvulus is quite common and is one of the common causes of large bowel obstruction [1].

Previous studies have suggested that the sigmoid colon in natives from region of higher incidence of sigmoid volvulus are longer than that in regions with less incidence

of sigmoid volvulus [15, 17]. Madiba [17] compare the length of recto-sigmoid colon among the native blacks with that of the white and Indians living in South Africa and reported that the blacks had the longest sigmoid colons.

It has been suggested that the reason for the longer sigmoid colon in region with high incidence of sigmoid volvulus such as Africa, Eastern Europe and India may be due to a higher consumption of high-fiber diets which is associated with formation of bulky stool [8, 27]. Possibly, the frequent distension of the colon by bulky stools eventually leads to elongation of the colon. Furthermore, Bassey [3] in his radiological study of the rectosigmoid colon length among the Calabar community in Nigeria, suggested, however, that the variation in length may be due to chronic use of laxative enema. These two theories appear not sufficient to explain why the sigmoid volvulus appears to affect more men than women, hence, the need to evaluate further plausible theories like the shape of sigmoid colon and sigmoid mesocolon [16].

Racial and sex differences in the length of sigmoid colon have also been implicated in failed colonoscopy in patients with elongated colons [10, 23, 25, 26]. Recently, facility and skill for colonoscopy are being developed in various parts of Nigeria. Performing colonoscopy in population with long and tortuous sigmoid colon may lead to a long learning curve and possible increase in complication following the procedure [25].

In view of the high incidence of sigmoid volvulus [3, 20] and the increase in availability of facility for colonoscopy in Nigeria, we wanted to find out the actual length and shape of the sigmoid colon and sigmoid mesocolon among Nigerian leaving in South west Nigeria. This will help to examine the concept of the putative anatomical basis for the sigmoid volvulus and failed colonoscopy in Nigeria.

Materials and methods

Study design and setting

This was a prospectively cross-sectional study carried out at Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, Osun State. The hospital provide tertiary level services being mostly accessed by patients from Osun, Ondo, Ekiti and some part of Kwara, Kogi, Oyo and Edo-States with an estimated population of about 10 million according to 2006 National population census.

The people Ife/Ijesa zone of Osun State where the institution is located are predominantly Yorubas with other Nigerian tribes and ethnic groups, however, also living permanently in the area. Peasant farming is the major occupation of the people. A sizeable number are engaged in commercial and small scale industrial enterprises, while the creams of the educated ones are the civil servants.

Subjects

Patients were recruited from those having abdominal surgery via a midline or lower midline incision at the General Surgical and Gynecological units of the hospital. The study on cadaver subjects was carried out in department of morbid anatomy, of the same hospital. The study subjects were living and fresh adult cadavers of 18 years old and above who are Nigerians. Details of the subjects' age, sex, past medical history, finding at laparotomy, cause of death as it may apply were recorded for both live and postmortem subject in a standard proforma.

Anatomical parameters

The perpendicular distances from the symphysis pubis to the xiphisternum and between left and right anterior, superior iliac spines were measured to assess the stature of the patient. Adequate exposures of the abdominal cavity were achieved in living subjects through a midline incision. All the measurements in both the living and cadaver subjects were carried out by the first author so as to avoid variability.

All measurements in living subjects were made at laparotomy using a sterile suture which was subsequently transcribed on a standard measuring tape and expressed in centimeters after the surgery. Similar measurements were taken for the cadaver subjects. The beginning and the end of the sigmoid loop were determined by noting the medial and lateral ends of the root of the sigmoid mesocolon. These marked the junctions of the fixed and mobile parts of the colon viz. the descending colon/sigmoid junction proximally and the recto sigmoid junction distally. The sacral promontory serves as the anatomical landmark for the end of the sigmoid colon.

The take off points of sigmoid colon was assessed and described as low level, mid-level, or high-level origin as previously reported by Madiba and Haffajee [15]. In a low-level origin, the descending colon came all the way down to the left iliac fossa and the sigmoid colon turn medially at any level below the left iliac crest. In subjects with a high-level origin of the sigmoid colon, the origin occur high in the descending colon close to its origin from the transverse colon above the level of the lower margin of the left rib cage, rendering the descending colon proper very short. Mid-level origin laid somewhere between the two.

The anatomical parameters of sigmoid colon and mesocolon measured followed the validated format of Bhatnagar [4]. These parameters include:

1. total length of the sigmoid colon as measured at the antimesenteric border (P1)
2. width of the sigmoid loop at the apex (P2)
3. width of the sigmoid colon at the proximal end (P3)
4. width of the sigmoid colon at the distal end (P4)
5. vertical length of the sigmoid mesocolon (P5)
6. maximum (middle) width of the sigmoid mesocolon (P6), and
7. width of the sigmoid mesocolon at the base of the sigmoid loop (root width) that is the width at the attachment to the posterior abdominal (P7).

The width of the sigmoid colon at the various measured points was taken as the indirect measure of the bowel lumen at that point. The vertical length of the sigmoid mesocolon (P5) was measured after putting the sigmoid loop on full stretch and measuring the distance between the mid-point of the root of the mesocolon and the farthest point of the mesocolon on the convexity of the sigmoid loop. This was where the apical width of the sigmoid colon also was measured. The root of the mesocolon was determined by the bifurcation of the left common iliac vessels. Similar measurements were made in the cadavers.

The attachment of the sigmoid mesocolon was assessed to see if there were any differences in its shape following the method of Madiba and Haffajee [15]. Three main shapes of the attachment are identified namely the "straight," inverted "U," or inverted "V" shapes. The following anatomical indices, henceforth called mesocolic indices (MCI), were calculated to determine the ratio of the length versus breadth of sigmoid mesocolon. The indices were expressed as percent [4].

Mesocolic Index A (*MCI-A*). The maximum width of the sigmoid mesocolon (P6) × 100/vertical length of the sigmoid mesocolon (P5).

Mesocolic Index B (*MCI-B*). The width of the sigmoid mesocolon at the root (P7) × 100/vertical length (P5).

Mesocolic Index C (*MCI-C*). The root width of the sigmoid mesocolon (P7) × 100/maximum width of the mesocolon (P6).

The mesocolon will be termed dolichomesocolic when the vertical length is greater than the width (MCI-A < 100) and brachymesocolic when the width is more than the vertical length (MCI-A > 100).

Inclusion and exclusion criteria

The cadavers included in this study were people dying of natural or unnatural causes and who were undergoing a medico-legal postmortem within 48 h of death without any formalin preservation. These were the cadavers with a previously normal colon which is considered free of any type of colonic disease. Cadavers excluded from the study were cadavers who

1. had laparotomy during life or for immediate past trauma (which may or may not have led to death),
2. had previous injury to the sigmoid colon,
3. had peritonitis,
4. had obviously colonic diseased (e.g., diverticular disease),
5. had adhesions for any reason, making inspection difficult.

Living subjects include consecutive patients who were undergoing abdominal surgery via a midline incision for disease that was not disease of the colon. Similarly, patients who had previous abdominal surgeries, diverticulosis of the sigmoid colon, inflammatory or malignant disease distorting colonic anatomy were excluded.

Statistical analysis

SPSS package version 16.0 was used to perform all the analysis. Descriptive statistics and tables were used to describe the measured parameters. Standard error of mean was used to measure the degree of dispersion for all measured parameter. The sex and the measured parameters including pattern of the sigmoid colon were compared using the student t test. Likelihood ratio Chi square was also used to compare categorical data. Pearson's correlation was used to determine the correlation between the age of the patients and various measured parameters of the sigmoid colon and sigmoid mesocolon. All differences were considered significant at $P < 0.05$.

Consent and ethical clearance

Voluntary informed consent was obtained from the patients after thorough explanation of the importance of the study to the patients. The consent form was translated into the vernacular language to enhance understanding for those who may not grasp the explanation in English language. Institutional consent was obtained from the OAUTHC Research/Ethics committee before the study commences. The autopsy cases were mandatory medicolegal autopsies.

Results

Anthropometric measurements

The age range of the living subjects was 24–80 years with a mean of 48.3 ± 1.7 years. In addition, the age range of cadaver subjects was 22–80 years with a mean of 47.0 ± 2.0 years. Table 1 showed the ranges and means of

Table 1 Measurements of sigmoid colon (cm) in live and cadaver subjects

Parameter	Live subjects ($n = 50$)		Cadaver subjects ($n = 50$)		P value (L vs. C)
	Range	Mean ± SE	Range	Mean ± SE	
Age	24–80	48.3 ± 1.7	22–80	47.0 ± 2.0	
Height	152–180	168.5 ± 1.0	154.0–182.5	168.0 ± 1.1	
Distance between the ASIS	21.0–38.0	28.2 ± 0.7	21.0–39.0	31.1 ± 0.8	
Distance between XS and PS	26.0–46.7	33.7 ± 0.8	24.0–55.5	38.5 ± 1.2	
Sigmoid colon length (P1)	30.5–65.0	48.9 ± 1.3	34.5–67.8	50.1 ± 1.6	
Width at apex (P2)	3.0–6.1	4.4 ± 0.1	3.0–7.0	5.3 ± 0.2	0.001
Width at proximal end (P3)	3.0–5.0	3.7 ± 0.1	3.0–5.5	4.4 ± 0.1	0.001
Width at distal end (P4)	3.2–5.6	4.2 ± 0.1	3.3–7.0	5.1 ± 0.2	0.001
Vertical length of mesocolon (P5)	10.0–22.5	16.8 ± 0.5	8.0–19.0	14.1 ± 0.5	0.001
Maximum width of mesocolon (P6)	7.0–18.7	11.7 ± 0.4	7.5–18.0	11.6 ± 0.4	0.006
Width of mesocolon at the root (P7)	5.0–10.0	7.5 ± 0.3	4.0–11.0	6.5 ± 0.3	0.009
Mesocolic Index-A (%)	48.3–116.9	70.4 ± 2.0	53.3–150.0	82.4 ± 3.1	0.002
Mesocolic Index-B (%)	27.5–90.0	46.1 ± 1.9	32.6–91.7	47.1 ± 1.9	
Mesocolic Index-C (%)	26.7–96.1	66.2 ± 2.1	23.4–93.0	55.1 ± 2.5	0.001

SE standard error of mean, *ASIS* anterior superior iliac spine, *XS* xiphisternum, *PS* pubic symphysis, *L* live subjects, *C* cadaver subjects

anthropometric measurements of both the living and cadaver subjects.

Sigmoid colon

As shown in Table 1, the value obtained for P1–P4 showed a wide range but 80 % of the living subjects have a total length of the sigmoid colon (P1) between 42.0 and 58.0 cm (mean 48.9 ± 1.3 cm), the width at the apex (P2) was between 4.0 and 5.0 cm (mean 4.4 ± 0.1 cm), the width at the proximal end (P3) between 3.2 and 4.0 cm (mean 3.7 ± 0.1 cm), and the width at the distal end (P4) was between 3.8 and 4.5 cm (mean 4.2 ± 0.1 cm). Statistical comparison of the width of the sigmoid colon (Table 2) showed that in living subject, the sigmoid colon is significantly wider at the apex (P2) and distal end (P4) than that at the proximal end (P3) ($P < 0.05$); the widths at the apex (P2) was found to be significantly wider than the distal end (P4) ($P < 0.05$). This suggests that the sigmoid colon widens as it proceeds distally toward the apex of the loop and tapers toward the rectum. When correlation of the length of the sigmoid colon (P1) as well as, the width of the sigmoid colon at apex (P2), proximal end (P3), and distal end (P4) were carried out with the height of the patients, it was not statistically significantly correlated ($P > 0.05$) (Table 2). However, the distance between the right and left anterior superior iliac spine and the distance between the xiphisternum and pubic symphysis were statistically significantly correlated from the length of the sigmoid colon (<0.05), suggesting that the higher the distance between the xiphisternum and pubic symphysis and the right and left anterior iliac spine, the longer the length of the sigmoid colon.

In 80 % of the cadavers, the length (P1) was between 38.0 and 62.0 cm (mean 50.1.1 ± 1.6), width at the apex (P2) was between 4.5 and 6.5 cm (mean 5.3 ± 0.2 cm), width at the proximal end (P3) was between 4.0 and 5.0 cm (mean 4.4 ± 0.1 cm), and width at the distal end (P4) was between 4.0 and 5.9 cm (mean 5.2 ± 0.3). As obtained in living subjects, the height of the subjects and the distance between the xiphisternum and pubic symphysis positively correlate with the length of the sigmoid colon and this was statistically significantly different ($P < 0.05$).

Sigmoid mesocolon

The measurements of the mesocolon length and width of sigmoid mesocolon show a wide range (Table 1) but in 80 % of living individuals, the range of the vertical length (P5) was 13.8–20.0 cm (mean 16.8 ± 0.5 cm), the maximum width (P6) was between 9.0 and 13.0 cm (mean 11.7 ± 0.4 cm), and the width at the root of the mesocolon (P7) was between 5.4 and 9.4 cm (mean 7.5 ± 0.3 cm). There was no significant correlation between the heights of the subjects, the distance between xiphisternum and pubic symphysis, the distance between the right and left anterior superior iliac spine and the length and width of the mesocolon ($P > 0.05$).

As shown in Table 1, 80 % of cadaver subjects have a vertical length of sigmoid mesocolon (P5) between 11.1 and 17.0 cm (mean 14.0 ± 0.8 cm), a middle width (P6) between 9.1 and 14.0 cm (mean 11.7 ± 0.6 cm), and the root width between 4.3 and 8.8 cm (mean 6.8 ± 0.5 cm).

Table 2 Comparative analyses of the measured parameters

Parameter compared	Live subjects ($n = 50$)		Cadaver subjects ($n = 50$)	
	r (Spearman correlation coefficient)	P	r (Spearman correlation coefficient)	P
P2 versus P3	0.687	<0.001*	0.426	0.002*
P3 versus P4	0.817	<0.001*	0.623	0.001*
P2 versus P4	0.783	<0.001*	0.426	0.002*
H versus P1	−0.048	0.743	0.521	0.001*
H versus P2	−0.038	0.798	0.252	0.073
H versus P3	−0.249	0.081	0.066	0.647
H versus P4	−0.090	0.535	−0.257	0.072
XS versus P1	0.365	0.009*	0.383	0.006*
XS versus P2	−0.063	0.664	0.388	0.005*
XS versus P3	0.078	0.590	0.390	0.005*
XS versus P4	0.064	0.657	0.236	0.099
LR versus P1	0.364	0.009*	0.159	0.272
LR versus P2	−0.012	0.933	0.139	0.337
LR versus P3	0.016	0.673	0.304	0.032*
LR versus P4	0.109	0.452	0.181	0.209

* Statistically significant

H height, *XS* distance between the xiphisternum and the pubic symphysis, *LR* distance between the right and left anterior superior iliac spine

When the heights of the subjects were correlated with dimension of mesocolon, it was found that the length of the sigmoid colon significantly correlated with height of the patients ($P = 0.001$).

Mesocolic indices

The mesocolic indices for living and cadaver subjects were presented in Table 1. In 80 % of the subjects the MCI-A and MCI-B were less than 100 %. This means that the overall width of the mesocolon was less than the vertical length and that a dolichomesocolic configuration was the most common pattern, although the brachymesocolic configuration (MCI-A > 100) was also seen. The MCI-C in both the living and cadaver subjects were less than 100 % and this means that in all individuals, the root of the mesocolon is narrower than the width.

Gender differences

The results of parameters based on gender were presented in Table 3. While the length of sigmoid colon (P1) and Mesocolic Index-A was statistically significantly different in two sexes ($P < 0.05$) in living subject, the length of the sigmoid colon and sigmoid mesocolon were statistically significantly longer in male when compared to female in cadaver subjects ($P = 0.018$, $P = 0.044$). Similarly, the maximum width and the root width of the mesocolon were statistically wider in males compared to those of females ($P = 0.006$, $P = 0.020$).

Living subjects versus cadavers

Comparison of measurements between living subjects and cadavers (Table 1) showed that the widths of the sigmoid colon, dimensions of sigmoid mesocolon, MCI-A and the MCI-C were significantly different in the two groups ($P < 0.05$).

Patterns of the mesocolon

Analysis of the mesocolon indices demonstrated only four patterns of the mesocolon in our studied population. The distribution of the various patterns in the living subjects and cadaveric subjects were presented in Table 4. The most common pattern was that which had the vertical length greater than the maximum width, and that is in turn greater than the width at the root. This pattern can be clearly labeled as dolichomesocolic and was seen in 36 of 50 living subjects, and 40 of 50 cadaveric subjects (Table 4).

Changes with age

The study of changes in various parameters with age was made in the living and cadaver subjects. The findings were presented in Table 5. The study showed positive correlation coefficients (r) with respect to age and the sigmoid colon length, as well as, the length of the sigmoid mesocolon and maximum width of the sigmoid colon in the cadaver subjects ($P < 0.05$).

Table 3 Comparison of male and female measurements in live and cadaver subjects (cm)

Parameter	Live subjects			Cadaver subjects		
	Male[b] ($n = 25$)	Female[b] ($n = 25$)	P (M vs. F)	Male[b] ($n = 25$)	Female[b] ($n = 25$)	P (M vs. F)
Age	43.30 ± 1.7	54.2 ± 2.6	0.001[a]	50.3 ± 3.0	43.7 ± 2.7	
Height	170.6 ± 1.3	166.1 ± 1.5		169.7 ± 1.7	166.4 ± 1.3	
Distance between the ASIS	27.5 ± 1.0	29.0 ± 1.0		30.0 ± 1.2	32.1 ± 1.1	
Distance between XS and PS	32.9 ± 1.2	34.6 ± 1.1		36.9 ± 1.9	40.0 ± 1.2	
Sigmoid colon length (P1)	49.0 ± 1.2	48.9 ± 2.5	0.040[a]	52.8 ± 2.5	47.5 ± 2.0	0.018[a]
Width at apex (P2)	4.4 ± 0.2	4.4 ± 0.2		5.5 ± 0.2	5.2 ± 0.3	
Width at proximal end (P3)	3.6 ± 0.1	3.7 ± 0.1		4.4 ± 0.4	4.3 ± 0.2	0.035[a]
Width at distal end (P4)	4.0 ± 0.1	4.4 ± 0.1		5.1 ± 0.2	5.1 ± 0.2	
Vertical length of mesocolon (P5)	16.9 ± 0.5	16.6 ± 0.6		15.1 ± 0.7	13.2 ± 0.6	0.044[a]
Maximum width of mesocolon (P6)	11.2 ± 0.6	12.3 ± 0.4		12.6 ± 0.6	10.6 ± 0.4	0.006[a]
Width of mesocolon at the root (P7)	7.6 ± 0.4	7.4 ± 0.4		7.2 ± 0.4	5.9 ± 0.4	0.020[a]
Mesocolic Index-A (%)	65.8 ± 2.2	75.7 ± 3.1	0.014[a]	87.7 ± 5.3	77.1 ± 3.2	
Mesocolic Index-B (%)	45.5 ± 1.9	46.9 ± 3.4		49. ± 3.3	44.7 ± 1.8	
Mesocolic Index-C (%)	69.6 ± 2.2	62.2 ± 3.5		60.0 ± 3.1	53.2 ± 3.9	

SE standard error of mean, *ASIS* anterior superior iliac spine, *XS* xiphisternum, *PS* pubic symphysis, *M* male, *F* female

[a] Mann–Whitney differences indicated only where significant

[b] Values are in mean ± SE

Table 4 Patterns of sigmoid mesocolon

Pattern	Parameter description	Live ($n = 50$)	Cadaver ($n = 50$)
1	P5 > P6 > P7, (MCI-A, B, C < 100)	36	40
2	P6 > P5 > P7 (MCI-A > 100, MCI-B, C < 100	12	8
3	P5 > P7 > P6 (MCI-C > 100, MCI-A, B < 100)	0	1
4	P5 > P6 = P7 (MCI-C = 100, MCI-A, B < 100)	2	1

Table 5 Correlation between age and various parameters

Parameter	Live subjects		Cadaver subjects	
	Coefficient of correlation (r)	P value	Coefficient of correlation (r)	P value
Sigmoid colon length (P1)	−0.064	0.658	0.538	0.001*
Width at apex (P2)	0.226	0.114	−0.013	0.927
Width at proximal end (P3)	0.190	0.187	0.193	0.927
Width at distal end (P4)	0.347	0.014	−0.213	0.147
Vertical length of mesocolon (P5)	−0.241	0.092	0.407	0.003*
Maximum width of mesocolon (P6)	0.001	0.995	0.637	0.001*
Width of mesocolon at the root (P7)	−0.303	0.032*	0.135	0.349
Mesocolic Index-A (%)	0.035	0.810	−0.16	0.913
Mesocolic Index-B (%)	−0.213	0.137	−0.250	0.080
Mesocolic Index-C (%)	−0.296	0.037	−0.118	0.415

* Statistical significant

Take off of sigmoid colon from descending colon

The level of origin of the sigmoid colon from the descending colon in living and cadaver subjects was shown in Fig. 1. In both subject groups, low-level take off of the sigmoid colon was most common pattern seen in our cohort. This suggest similar take off in both living and cadaveric subjects.

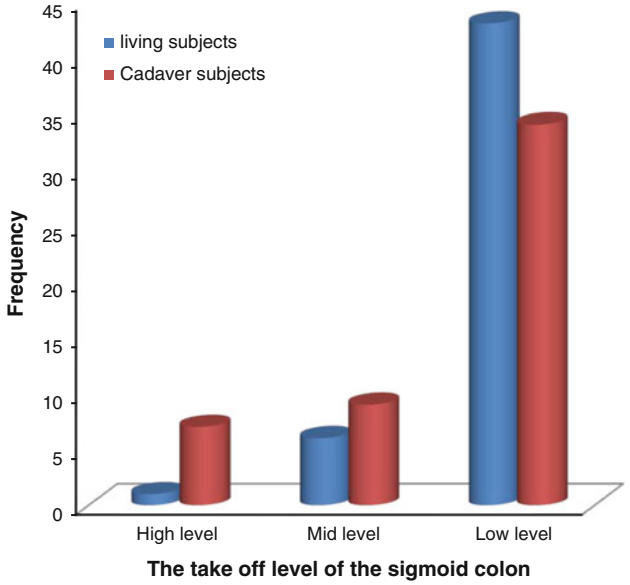

Fig. 1 Comparison of (origin) take off of the sigmoid colon from the descending colon in the living and cadaver subjects

Shape of the inter sigmoid recess

Figure 2 describes the various shapes of the inter-sigmoid recess in both living and cadaver subjects. About 82 % of the living subjects and 74 % of cadaver subjects have U-shaped configuration of the intersigmoid recess.

Discussion

In this study, we have measured the sigmoid colonic parameter in living and cadaver subjects and it was found that the length of the sigmoid colon was not statistically significantly different in both subject groups. The mean

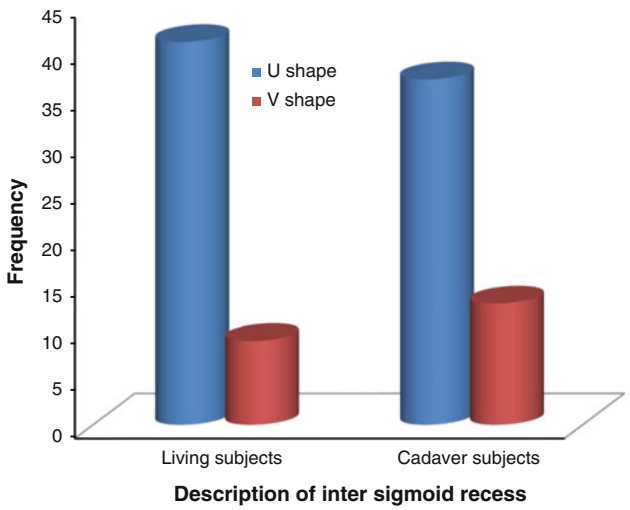

Fig. 2 Description of inter sigmoid recess in the study population

length of the sigmoid colon in this study was 48.9 cm in living subjects and 50.1 cm in cadaver subjects. These figures were greater than the average of 40 cm reported by Williams [29]. Similarly, the dimension among the study population was much greater than the length of sigmoid colon among the Orientals and Western population as reported by Saunders [24], who found that the median combine length of the rectum and sigmoid colon among the Orientals and Western population was 32 and 34 cm, respectively. Madiba and Haffajee [16] found the median length of sigmoid colon among the male Native African, South African Indian and South African White to be 29, 18, and 18 cm, respectively.

The sigmoid colonic length obtained from this study is comparable with dimension obtained among the Indians by Bhatnagar [4] who reported the mean sigmoid colonic length of 47 cm. The occurrence of long redundant sigmoid colon found in our population as compared with that of Indian population may be responsible for the frequent occurrence of sigmoid volvulus in our environment. In a recent work by Akinkuotu [2], where they compared the sigmoid colonic dimension in normal non-volvulized Malawians subject with those with sigmoid volvulus, they found that the mean sigmoid colonic lengths were 40 and 86 cm, respectively. The higher dimension of the sigmoid colon obtained in sigmoid volvulus subject may be due to close loop obstruction which lead to distension of the lumen by gas and fluid. Hence, the measurements may not be reflective of the true dimension in normal Malawians as evidenced by the length obtained from the control subjects.

The index study showed that the width of the sigmoid colon was widest at the apex and narrows proximally and distally. The reason for this difference may lie in the physiological formation of a wider, more solid and bulky column of feces needing more space, with inevitable stagnation pending evacuation. The wider space in the apex occupied by stools may set stage for the formation of volvulus.

The median vertical length of the sigmoid mesocolon in this study was 16.8 cm in living subjects and 14.1 cm in cadaver subjects. The dimensions were higher than the 11 cm recorded for the sigmoid mesocolon of the Western subjects and 12 cm for the Oriental subjects as reported by Saunders [24] and slightly higher than 13 cm among Indian and 13.1 cm among the Malawians reported by Bharnagar [4] and Akinkuotu [2], respectively. The occurrence of a longer and wider sigmoid mesocolon on a narrow root width similarly set the stage for the occurrence of sigmoid volvulus in our subject's population.

Another interesting finding of this study is the positive correlation of the distances between the right and left anterior superior iliac spine, as well as, distance between the xiphisternum and pubic symphysis with sigmoid colon

length. Similarly, we found that when the total length increases, all other parameters such as the width of the colon and all the dimensions of the mesocolon increase. Exploiting the factor by which the dimension of the sigmoid colon increases in respect to the distance between right and left anterior superior iliac spine in a large population series may help to predict the risk of sigmoid volvulus in any individual in the nearest future.

Worldwide, sigmoid volvulus is common among men. In this study, the sigmoid colonic length in male was statistically longer than that of female. It may be possible that the longer colonic length in men may be responsible for increase in occurrences of sigmoid volvulus. It has also been suggested that the reduction in occurrences of sigmoid volvulus in women may be due to the presence of wide capacious pelvis and lax abdominal wall allow greater chance for untwisting of the colon [6, 7, 21]. In addition, gender-specific cultural patterns of defecation which may affect the recto-sigmoid junction differently in males and females may also explain the observation [28]. Furthermore, it has also been recently found that there is greater occurrence of tethering among the female sigmoid colon due to repeated inflammation. This tethering prevents torsion of the sigmoid colon rendering it less susceptible to sigmoid volvulus [16].

Other gender-specific findings of this study which has also been corroborated by previous study include wider sigmoid colon among male as compared with female [22, 30]. This study also showed that the most common sigmoid colonic pattern in both males and females is the dolichomesocolic pattern.

This study showed that the length and width of the sigmoid colon, as well as that of the dimension of the mesocolon changes as patients' ages from 18 to 80 years with the largest dimension occurring in the elderly population. Similar positive correlation had been noted by Sadahiro [22]. The occurrence of redundancy in the sigmoid colon and sigmoid mesocolon in this age group may explain why sigmoid volvulus occurred more commonly in the elderly population. In the cadaver study of Jit and Grewal [12], it was shown that colonic length increases in the female as age advances with no changes observed in the male after the age of 18 years. Some studies have, however, not found such correlation between the age and sigmoid colon dimension [4, 30]. The differences observed in the various studies could either be due to the differences in methodology used in each study or may actually be due to ethnicity.

As opposed to findings of Bhatnagar [4], only four mesocolic patterns were demonstrated in this study. It does confirm the description by Williams [29] that a well-formed classical sigmoid loop has its maximum convexity just a little proximal to its apex and the mesocolon has its maximum width in that area. The vertical length of the mesocolon in this pattern is greater than its width, i.e., it is of a dolichomesocolic configuration.

This study demonstrated that the take off of the sigmoid colon from the descending colon could be variable. Classically, the sigmoid colon begins at the left iliac crest and ends at the sacrum [5, 19, 29]. This low take off was found in majority of our subjects. Conversely to our finding, Madiba and Haffajee [15] found that high-level take off is most common among the native South Africans.

Whereas the literature describes the inverted V shape of the attachment of the sigmoid mesocolon as common or even constant [5, 19, 29], this study has demonstrated anatomical variability in its shape. The V shape was the least common, occurring in only 18 % of cases in living subjects and 26 % of cases in postmortem subjects. No occurrence of the straight sigmoid mesocolon was observed in our study as previously reported [15]. Our findings are congruent to the findings of Madiba and Haffajje [16], who found that the U shape was most common among Africans and was significantly more so in this group compared with whites and Indian living in South Africa.

This study, no doubt, is limited by the small sample size which was brought about by the strict inclusion and exclusion criteria. Further study involving lager sample size will be needed to validate the findings of this study.

In conclusion, this study showed that the sigmoid colon and sigmoid mesocolon length in our study population is longer, especially among the male, than previously reported in literature. In addition, we found that the widest point of the sigmoid colon was at the apex and that it narrows proximally and distally. Similarly, we found that the occurrence of dolichomesocolon was higher among our cohort. Furthermore, we found that low take off was the most common origin of sigmoid colon seen in Nigeria. All this may possibly predispose to increase frequency of sigmoid volvulus and high occurrence of failed colonoscopy. In this study, we found that the length of sigmoid colon changes with advance in age. We also found that only two shapes of inter sigmoid recess were demonstrated with the U shape been the most common. Further study will be required to identify possible factors responsible for the longer sigmoid colon found among our study population such as diet and bowel habit.

Conflict of interest No conflict of interest identified.

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