

## The relationship of the anatomical dimensions of the sigmoid colon with sigmoid volvulus

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**Aim:** To investigate the role of the anatomical dimensions of the sigmoid colon in the development of sigmoid volvulus (SV).

**Materials and methods:** The present prospective study was performed with 447 patients who underwent abdominal surgery. The length of the sigmoid colon (SCL), the height of the sigmoid mesentery (SMH), the width of the sigmoid mesentery (SMW), and the width of the base of the sigmoid mesentery (SBW) were measured in the operation. Additionally, SCL/SBW, SMH/SBW, and SMH/SMW rates were calculated.

**Results:** The mean SCL, SMH, SMW, and SBW values were  $43.7 \pm 8.9$  cm,  $19.3 \pm 4.6$  cm,  $15.6 \pm 2.8$  cm, and  $8.6 \pm 1.5$  cm, respectively, while the mean SCL/SBW, SMH/SBW, and SMH/SMW rates were  $5.3 \pm 1.8$ ,  $2.3 \pm 0.9$ , and  $1.3 \pm 0.3$ , respectively. The mean SCL and SMH values and SCL/SBW, SMH/SBW, and SMH/SMW rates were significantly higher in the patients of 40 years of age and older than those of the patients under 40 years of age ( $P < 0.01$ ), in the males than in the females ( $P < 0.01$ ), and in the patients with a history of SV than in the patients with no history of SV ( $P < 0.01$ ).

**Conclusion:** This study documented clear relationships between some anatomical dimensions of the sigmoid colon and SV in living subjects.

**Key words:** Sigmoid anatomy, sigmoid colon, sigmoid mesentery, volvulus

### Sigmoid kolonun anatomik boyutları ile sigmoid volvulus arasındaki ilişki

**Amaç:** Bu çalışma, sigmoid kolonun anatomik boyutlarının, sigmoid volvulus (SV) gelişmesindeki rolünü araştırmak amacıyla planlandı.

**Yöntem ve gereç:** Bu prospektif çalışma, karın cerrahisi geçiren 447 hasta üzerinde gerçekleştirildi. Ameliyatlarda sigmoid kolon uzunluğu (SKU), sigmoid mezenter yüksekliği (SMY), sigmoid mezenter genişliği (SMG) ve sigmoid mezenter taban genişliği (STG) ölçüldü. Ek olarak, SKU/STG, SMY/STG ve SMY/SMG oranları hesaplandı.

**Bulgular:** Ortalama SKU, SMY, SMG ve STG değerleri sıra ile  $43,7 \pm 8,9$  cm,  $19,3 \pm 4,6$  cm,  $15,6 \pm 2,8$  cm and  $8,6 \pm 1,5$  cm iken, ortalama SKU/STG, SMY/STG ve SMY/SMG oranları sıra ile  $5,3 \pm 1,8$ ,  $2,3 \pm 0,9$  ve  $1,3 \pm 0,3$  idi. Ortalama SKU ve SMY değerleri ile SKY/STG, SMY/STG ve SMY/SMG oranları, 40 yaş ve üzerindeki hastalarda, 40 yaş altındakilerden ( $P < 0,01$ ), erkeklerde kadınlardan ( $P < 0,01$ ) ve SV hikayesi olanlarda, SV hikayesi olmayanlardan ( $P < 0,01$ ) belirgin ölçüde yüksekti.

**Sonuç:** Bu çalışma, yaşayan insanlarda sigmoid kolonun bazı anatomik boyutları ile SV arasında belirgin bir ilişki varlığını ortaya koydu.

**Anahtar sözcükler:** Sigmoid anatomi, sigmoid kolon, sigmoid mezenter, volvulus

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## Introduction

Sigmoid volvulus (SV) is the wrapping sigmoid colon that wraps itself and its own mesentery causing a closed loop obstruction (1). Although some etiological factors have been suggested including sigmoid anatomy, age, gender, geographical variation, dietary habit or defecation habits, the actual aetiology of SV remains speculative (2-4). This study was designed to investigate the relationship between some anatomical dimensions of the sigmoid colon and SV.

## Materials and methods

The present prospective study was performed with 447 surgically treated patients in the Department of General Surgery, School of Medicine, Atatürk University, in a 24-month period, between January 2007 and January 2009.

The patients who underwent abdominal surgery under general anaesthesia were included in the study on a voluntary basis except the patients who were under 20 years of age, in whom adequate anamnesis was not obtained, who had a history of abdominal surgery, whose vital findings were unstable, who had disease(s) in the rectosigmoid region, who had generalized peritonitis, and in whom reaching the sigmoid colon was not technically possible in the operation. The patients who were operated on through elective sigmoid resection after nonsurgically detorsioned sigmoid volvulus (SV) were also included in the study.

The age, gender, previous SV episodes history, and the modality of the surgical procedure (elective or emergency, open, or laparoscopic) of all the patients were recorded. The anatomical measurements were performed by a sterile tape measure in open cases and by a pair of laparoscopic forceps in laparoscopy cases. The measurements were established during the diagnostic laparotomy or laparoscopy period at the beginning of the operation in elective cases, while these procedures were delayed after the surgical proceedings in emergency or infected cases, and the findings obtained were recorded. The time of the measurement procedure was also recorded.

The anatomical measurements used in the study were as follows: the length of the sigmoid colon (SCL); the distance between the ascending colon

and rectum along the antimesenteric line of the sigmoid colon, the height of the sigmoid mesentery (SMH); the distance between the tip and the base of the sigmoid mesentery, the width of the sigmoid mesentery (SMW); the distance between the edges of sigmoid mesentery in the largest route, and the width of the base of the sigmoid mesentery (SBW); the distance between the edges of the base of sigmoid mesentery (Figure). Additionally SCL/SBW, SMH/SBW, and SMH/SMW rates were determined.

ANOVA, t, and chi-square tests were used in statistical analysis.

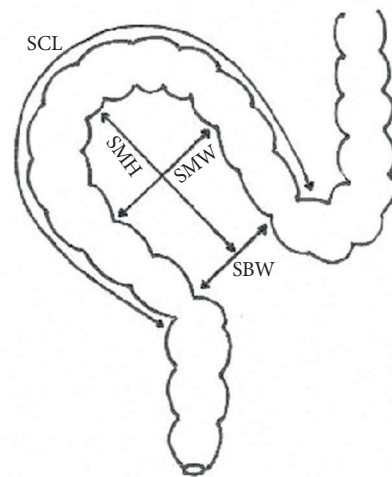


Figure. Measured anatomical parameters of the sigmoid colon. (SCL: the length of the sigmoid colon, SMH: the height of the sigmoid mesentery, SMW: the width of the sigmoid mesentery, SBW: the width of the base of the sigmoid mesentery).

## Results

The 447 patients included in this study comprised 22.1% of the total 2023 patients who underwent abdominal surgery within the period stated. The mean age of the patients was  $51.9 \pm 16.3$  years (range: 20-88 years). Of the patients, 181 (40.5%) were male and 266 (59.5%) were female. Fourteen patients (3.1%) had a history of sigmoid volvulus (SV) episodes. In 447 patients, 349 operations (78.1%) were elective and 98 (21.9%) were emergency; 268 (60.0%) were open and 179 (40.0%) were laparoscopic. The measurement time was 1-2 min in open and 1-4 min in laparoscopy cases.

The distribution of the anatomical measurements of the sigmoid colon according to the decades and

their statistical analyses are presented in Table 1. As seen, there were statistically significant correlations between the ages and the length of the sigmoid colon (SCL), the height of the sigmoid mesentery (SMH), and the width of the sigmoid mesentery (SMW) values and the SCL/SBW, SMH/SBW, and SMH/SMW rates ( $P < 0.01$ ), while the width of the base of the sigmoid mesentery (SBW) values were not statistically different ( $P > 0.05$ ).

The distribution of the anatomical measurements according to the age, gender, and history of volvulus are shown in Table 2. As seen, the SCL, SMH, and SMW values and the SCL/SBW, SMH/SBW, and SMH/SMW rates were significantly higher ( $P < 0.01$ ) in the patients of 40 years of age and older than those in the patients under 40 years of age. Similarly, the SCL and SMH values and the SCL/SBW, SMH/SBW, and SMH/SMW rates were significantly higher, and the SBW values were significantly lower ( $P < 0.01$ ) in the males than in the females. On the other hand, the SCL and SMH values and the SCL/SBW, SMH/SBW, and SMH/SMW rates were significantly higher ( $P < 0.01$ ) and the SBW values were lower ( $P < 0.05$ ) in the patients with a history of volvulus than in the patients with no history of volvulus.

In 13 (92.9%) of the total 14 patients with a history of volvulus, the SCL values were higher than the mean + SD values of the patients with no history of volvulus, and in 12 patients (85.7%) with a history of volvulus, the SMH values were higher than the mean + SD values of those without a history of volvulus, while in 10 patients (71.4%) with a history of volvulus, the SBW values were lower than the mean - SD values of those without a history of volvulus. Similarly, in 11 (78.6%) of the total 14 patients with history of volvulus, the SCL/SBW rates were higher than the mean + SD rates of the patients with no history of volvulus, while in 12 patients (85.7%) with a history of volvulus, the SMH/SBW rates were higher than the mean + SD rates of those without a history of volvulus, and in 13 patients (92.9%) with a history of volvulus, the SMH/SMW rates were higher than the mean + SD rates of those without a history of volvulus. Additionally, there was a difference in the rate of positive history of volvulus between the patients of 40 years of age and older and the patients under 40 years of age (4.1% vs. 0.0%;  $\chi^2 = 4.5$ ;  $P < 0.05$ ). Similarly, this rate was significantly higher in the males than in the females (6.1% vs. 1.1%;  $\chi^2 = 8.7$ ;  $P < 0.01$ ).

Table 1. Anatomical measurements of the sigmoid colon according to the decades.

Age (Years)	Number	SCL (cm)	SMH (cm)	SMW (cm)	SBW (cm)	SCL/SBW	SMH/SBW	SMH/SMW
20-29	50	35.7 ± 5.1	16.8 ± 2.1	14.7 ± 2.1	8.7 ± 1.2	4.2 ± 1.1	2.0 ± 0.4	1.2 ± 0.2
30-39	60	38.6 ± 5.6	16.8 ± 2.9	14.8 ± 3.0	8.6 ± 1.9	4.7 ± 1.1	2.0 ± 0.4	1.2 ± 0.2
40-49	79	41.8 ± 5.7	18.1 ± 3.1	15.1 ± 2.1	8.3 ± 1.3	5.2 ± 1.4	2.2 ± 0.6	1.2 ± 0.2
50-59	96	43.9 ± 7.6	19.1 ± 4.7	15.5 ± 3.1	8.4 ± 1.3	5.4 ± 1.6	2.4 ± 0.9	1.3 ± 0.3
60-69	85	47.5 ± 9.9	21.3 ± 5.0	16.0 ± 2.7	8.7 ± 1.4	5.7 ± 2.3	2.6 ± 1.1	1.3 ± 0.3
70-79	64	49.8 ± 8.2	21.4 ± 4.5	16.7 ± 2.6	9.0 ± 1.6	5.8 ± 1.7	2.5 ± 0.8	1.3 ± 0.3
80-88	13	54.4 ± 9.9	25.1 ± 6.9	17.5 ± 2.9	9.1 ± 2.7	6.8 ± 3.8	3.2 ± 2.2	1.5 ± 0.5
Total	447	43.7 ± 8.9	19.3 ± 4.6	15.6 ± 2.8	8.6 ± 1.5	5.3 ± 1.8	2.3 ± 0.9	1.3 ± 0.3
Min., max.		20-84	9-42	6-26	4-16	2.4-18.0	1.1-9.0	0.7-3.0
Anova test		F = 29.3, P < 0.01	F = 18.2, P < 0.01	F = 5.6, P < 0.01	F = 1.2, P > 0.05	F = 8.1, P < 0.01	F = 6.5, P < 0.01	F = 5.0, P < 0.01

SCL: the length of the sigmoid colon, SMH: the height of the sigmoid mesentery, SMW: the width of the sigmoid mesentery, SBW: the width of the base of the sigmoid mesentery

Table 2. Anatomical measurements of the sigmoid colon according to age, gender, and history of volvulus.

Parameter	Number	SCL (cm)	SMH (cm)	SMW (cm)	SBW (cm)	SCL/SBW	SMH/SBW	SMH/SMW
40 years of age and older	341	45.7 ± 8.8	20.4 ± 4.8	15.8 ± 2.8	8.6 ± 1.5	5.6 ± 1.9	2.4 ± 1.0	1.3 ± 0.3
Under 40 years of age	106	37.4 ± 5.6	16.8 ± 2.6	14.8 ± 2.6	8.7 ± 1.6	4.5 ± 1.1	2.0 ± 0.4	1.2 ± 0.2
t test		t = 11.4, P < 0.01	t = 8.9, P < 0.01	t = 3.2, P < 0.01	t = 0.3, P > 0.05	t = 7.1, P < 0.01	t = 6.4, P < 0.01	t = 3.8, P < 0.01
Male	181	48.2 ± 9.9	21.5 ± 5.3	15.6 ± 2.9	8.1 ± 1.7	6.3 ± 2.3	2.8 ± 1.2	1.4 ± 0.3
Female	266	40.7 ± 6.7	17.8 ± 3.2	15.5 ± 2.7	8.9 ± 1.3	4.6 ± 0.9	2.0 ± 0.4	1.2 ± 0.2
t test		t = 8.8, P < 0.01	t = 8.3, P < 0.01	t = 0.1, P > 0.05	t = 5.3, P < 0.01	t = 8.7, P < 0.01	t = 8.3, P < 0.01	t = 8.4, P < 0.01
History of volvulus	14	70.6 ± 10.5	33.2 ± 6.2	15.6 ± 3.7	6.9 ± 2.6	11.6 ± 4.0	5.5 ± 2.3	2.2 ± 0.6
No history of volvulus	433	42.9 ± 7.4	18.8 ± 3.7	15.6 ± 2.7	8.7 ± 1.5	5.1 ± 1.3	2.2 ± 0.6	1.2 ± 0.2
t test		t = 9.8, P < 0.01	t = 13.9, P < 0.01	t = 0.1, P > 0.05	t = 2.6, P < 0.05	t = 6.1, P < 0.01	t = 5.3, P < 0.01	t = 6.1, P < 0.01

SCL: the length of the sigmoid colon, SMH: the height of the sigmoid mesentery, SMW: the width of the sigmoid mesentery, SBW: the width of the base of the sigmoid mesentery

In the present series, in 368 patients (82.3%) sigmoid mesentery was dolichocolic (longer than wide), while in 79 (17.7%), the mesentery was brachycolic. Additionally, a dolichomesocolic pattern was (wider than long) present in all of the patients with a history of volvulus.

## Discussion

Sigmoid volvulus (SV) is an unusual but an important large bowel obstruction form that is characterized with twisting sigmoid colon around itself and its own mesentery (1). SV accounts for 2% to 5% of large bowel obstructions in western and 20% to 50% in eastern countries (2,5-8). The cause of SV is multifactorial and still remains controversial (2-4).

The anatomical constitution of sigmoid colon is the most contentious point in the development of SV (2-6). The length of the sigmoid colon (SCL) is one of the anatomical parameters, and elongation of the sigmoid colon is considered an important factor by many authors (2-4,9-12). In a study on 70 live subjects and cadavers, Bhatnagar et al. (3) found the SCL at a mean of 46.6 cm and they reported this parameter to be longer in Indians than in other populations. In another radiological study, Madiba et al. (4) reported the total rectosigmoid length with a

mean of 57 cm in Africans, which was longer when compared to the length in the other populations. Our SCL findings with a mean of 43.7 cm in Turks, in whom SV is common as in Indians and Africans are supportive of the reports above mentioned. Ertem et al. (11) reported similar results in Turks. On the other hand, a SCL rate higher than mean + SD in 92.9% of our patients with a history of volvulus shows the importance of sigmoid redundancy in SV. Dolichomesentery, another anatomical characteristic of sigmoid colon, is described as 'mesentery that is longer than wide', and is common in the countries in which SV is endemic (3,4,11,13,14). Bhatnagar et al. (3) found that the dolichomesocolic pattern was the commonest in Indians. Similarly, a high ratio of dolichomesentery was determined in Africans by Madiba et al. (4) and by Tubes (13); in Bulgarians by Katsarski and Singh (14), and in Ethiopians by Riedl (15). In the present series, the rate of dolichomesentery (82.3%) was high, as reported by Ertem et al. (11) in Turks. Additionally, the high value (92.9%) of the height of sigmoid mesentery (SMH)/the width of sigmoid mesentery (SMW) and the presence of a dolichomesocolic pattern, a rate of 100.0% in the patients with a history of volvulus show the role of this criterion in the development of SV. The width of the base of the sigmoid mesentery (SBW) is the 3rd anatomical criterion, and the narrowing of the base of

the sigmoid mesentery was shown to be an effective factor in the disease (2,3). The lower SBW values and the high rate (71.4%) of the SBW value under mean - SD in our patients with a history of volvulus support this theory. Consequently, an elongated sigmoid colon with a dolichocolic mesentery and a narrow base is regarded as a prerequisite for SV (2-4). The above mentioned anatomical characteristics may be acquired or rarely congenital (1,16,17).

It is well known that SV is common in adults and the highest incidence is seen in the 4th-8th decades (1,2,5,6,18-20). Our study showed significant correlations between age and SCL values as well as SCL/SBW, SMH/SBW, and SMH/SMW rates, which may explain the relationship between age and SV. Similarly, Sadahiro et al. (21) reported a positive correlation of age with colon length. However, Bhatnagar et al. (3) showed that the measurements of the sigmoid colon and its mesentery did not change significantly within the age range of 16-60 years. Similarly, Yamazaki et al. (22) reported a negative correlation of age with colon length.

SV is common in males at ratios ranging from 2/1 to 10/1 (1,3,5,6,18-20,23-26), possibly because of the dolichomesocolon, which is common in males and may cause torsion (3). Bhatnagar et al. (3) found that sigmoid mesocolon of male was generally dolichocolic, whereas that of female was generally brachycolic. Similarly, Madiba et al. (4) reported the total rectosigmoid length with a mean of 74 cm in males, which was longer when compared to a mean of 55 cm in females. In the present study, the SCL and SMH values and SCL/SBW, SMH/SBW, and SMH/SMW rates were significantly higher and the SBW values were significantly lower in the males than in the females, in whom SV is uncommon, which is supportive of the reports mentioned above. On the other hand, although high occurrence in men is attributed to smaller pelvic inlet that does not allow mobility of the enlarged sigmoid colon causing a spontaneous detorsion (23), and low occurrence in women is attributed to capacious pelvis and a lax abdominal wall that allows spontaneous untwisting of the volvulus (5), according to Raveenthiran et al. (5) and Tegegne (27), this hypothesis does not explain the excessive male ratio of SV, and the resulting irregular emptying and faecal overload could predispose to SV

in men. Another factor is pregnancy, which makes the torsion more likely (8). In pregnant women, it is felt that the enlarged uterus may push the redundant sigmoid colon out of the pelvis and cause twisting (28).

SV is characterized with an interesting geographic dispersion. African, Asian, Eastern and Northern European, Middle Eastern and South American countries, and Turkey are endemic regions for the disease (2,5,6,18-20,24). It is thought that high altitude may be a possible reason of this dispersion, and it may lead to high intraluminal pressure that causes elongation of the sigmoid colon (29). Although it is not clear, this theory may be acceptable for some regions such as the Andes (30), as well as our region, Eastern Anatolia, where the altitude is high. Another factor that affects the dispersion of SV may be dietary or defecation habits (1,5,6,24).

High-fibre vegetable diet may cause elongation and dilatation of the sigmoid colon by provoking faecal loading (1,24,31). Vegetable fibre in the diet has been implicated as an aetiological factor in some countries such as India, Iran, Turkey, and Africa (1,2). This theory may also explain the relationship with socioeconomic status and SV and may answer why SV is common in developing or underdeveloped countries as well as in rural areas (1,2,5,31). On the other hand, voluntary or involuntary constipation habits which are seen in elderly people or in neurologic, psychiatric, or metabolic diseases may cause chronic constipation that results in elongation of the sigmoid colon (1,2,5,6,24,31).

Other rare predisposing factors of SV are postoperative adhesions, internal herniations, omphalo-mesenteric abnormalities, malrotations, intussusceptions, appendicitis, and carcinomas (1,24).

In conclusion, the present study documented clear relationships between elongated sigmoid colon with high and narrow mesentery, and narrow mesentery base and SV. To the best of our knowledge, this is the only study that compares the anatomical dimensions of the sigmoid colon and investigates their role in SV in living individuals in Turkey. Further studies with larger series will help to determine the role of the sigmoid anatomy in SV.



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