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Risk factors of sigmoid volvulus in patients with idiopathic megacolon

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ABSTRACT *AIM: to identify risk factors of sigmoid volvulus in patients with idiopathic megacolon/megarectum.*
PATIENTS AND METHODS: the retrospective study included 151 patients with idiopathic megacolon/megarectum (2002-2023). The diagnosis of megacolon/megarectum was confirmed with a barium enema. Hirschsprung's disease was excluded after anorectal manometry and (if needed) rectal wall biopsy by Swenson.
RESULTS: forty-seven (31.1%) idiopathic megacolon/megarectum patients have had sigmoid volvulus in history or during current admission. In univariate analysis the significant correlation was revealed between sigmoid volvulus rate and age, rate of defecation without assistance, rate of integral parameter "defecation difficulties", Wexner constipation scale rate ($p < 0.05$). There also was significant correlation between sigmoid volvulus rate and sigmoid length, sigmoid width, rectum width and rate of distal retention in gut transit test ($p < 0.05$). Due to multivariate analysis (multiple logistic regression) the best fit has the model, which sigmoid length, sigmoid width, and rectum width were included (Somers' D — 0.867, KS statistic — 0.718, $p < 0.0001$). Sigmoid width (OR = 2.29; CI 1.38–3.82) and rectum width (OR = 0.39; CI 0.22–0,72) were independent factors affected sigmoid volvulus rate. In the ROC analysis the area under the curve was 0.93 with a sensitivity of 82.4% and specificity of 89.2% in Youden's point of 0.719. The nomogram for sigmoid colon volvulus risk prediction in idiopathic megacolon/megarectum patients was build up based this model.
CONCLUSION: idiopathic megacolon is associated with risk of sigmoid volvulus. The risk of sigmoid volvulus more than 90% estimated with the nomogram can be considered as a reason for elective surgery in idiopathic megacolon/megarectum patients without sigmoid volvulus in anamnesis.

KEYWORDS: *Idiopathic megacolon, idiopathic megarectum, sigmoid volvulus*

CONFLICT OF INTEREST: *The authors declare no conflict of interest*

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INTRODUCTION

A large intestine volvulus is a rotation of the intestine around the axis of the mesentery root of the intestine (mesenteric axial volvulus), or around the axis of the intestine itself (organo-axial volvulus) or, less often, across the axis of the intestine (inflection, transverse volvulus). Intestinal volvulus leads to acute intestinal obstruction, and depending on the degree of volvulus, the obstruction can take the form of both obturation and strangulation. With a volvulus of 180°–270°, the violation of intestinal blood supply is usually less pronounced, develops later and the clinical picture is close to obstruction. With a volvulus of over 270°, ischemia develops more rapidly, quickly leading to necrosis of the intestinal wall, perforation and peritonitis, accompanied by severe manifestation and a high risk of an adverse outcome. Most often, the sigmoid colon volvulus occurs in up to 90% of cases. The second most common, although much rarer, is the volvulus of the cecum,

Table 1. *The lumen width of the various parts of the large intestine in normal (n = 160) [17]*

Part of the intestine	Lumen width (cm)
Caecum	4.0–9.0
Ascending colon	2.5–9.0
Transverse colon	2.5–8.5
Descending colon	1.5–6.0
Sigmoid colon	1.5–6.0
Rectum	4.5–8.5

more precisely, the ileocecal part of the intestine (5–15%). The transverse colon and the area of the splenic flexure account for no more than 5% of cases [1]. The prevalence of volvulus varies significantly in geography. In 'endemic' areas, such as Russia, they account for up to 42% in the structure of acute intestinal obstruction [2–5]. At the same time, in the USA and Western countries, the incidence of volvulus is noticeably lower — about 10–15% of all cases of large intestine obstruction. At the same time, the age of patients is usually higher, with a peak incidence in the 6th — 8th decades of life [6–9]. It is natural that a significant proportion of patients at this age have various concomitant diseases, which is largely due to the continuing high mortality rate.

The problem of volvulus is determined by the severity of complications and the tendency to relapse after conservative treatment. Thus, up to 25% of patients already show a picture of large intestine ischemia, perforation, peritonitis or septic shock upon admission [10]. At the same time, even in a favorable situation of successful endoscopic detorsion of the volvulus, the recurrence rate is 45–71% [11–15]. And the mortality rate in the case of conservative treatment remains at the level of 9–36% [11–15]. In this regard, according to both the international consensus on sigmoid colon volvulus in 2023 [10] and the previous guidelines of 2016 [1], already 1 volvulus in the history is a strong indication for elective surgery which means colon resection. Various kinds of fixing procedures have proven to be ineffective. Megacolon is considered as one of the risk factors for sigmoid colon volvulus [2,16]. Indeed, it is the volvulus that is the main manifestation of the complicated idiopathic megacolon. And the complicated disease or its high risk, in turn, serve as the main indication for elective surgery in such patients, since megacolon itself does not pose a threat to health. But we could not find any other prognostic signs that would allow us to assess the risk of volvulus, except for the fact of a history of volvulus in the available literature. Therefore, the aim of the study was to identify risk factors for volvulus in patients with idiopathic megacolon and, based on this, to clarify the indications for elective surgical treatment.

PATIENTS AND METHODS

A retrospective single-center study included 151 patients with idiopathic megacolon/megarectum between 2002 and 2023. The study did not include patients who had undergone colon resection with colostomy before going to the Center, including for volvulus.

The diagnosis of megacolon/megarectum was proved on the basis barium enema if the width of one or another part of the large intestine exceeded the normal parameters determined by X-ray morphometric study (Table 1) [17].

Hirschsprung's disease as a cause of megacolon/megarectum was excluded by barium enema (n = 151), anorectal manometry (n = 151) and, if necessary, Swenson's biopsy of the rectal wall (n = 24).

The analysis took into account gender, age and the following symptoms: the presence or the absence of constipation, the safety of an independent stool and the urge to defecate, the incidence of defecation, symptoms of abdominal discomfort and difficulty in defecation, anal incontinence, soiling. In 97 patients, clinical manifestation was assessed using a special questionnaire with a gradation of incidence and severity of symptoms.

Table 2. *Estimation of gut transit time in points*

Transit time (hours)	Before 24	24–48	49–72	73–96	Over 96
Points	1	2	3	4	5

This made it possible to make a quantitative analysis of symptoms on a point scale. The calculation method was described in more detail by us earlier [18]. Thus, the severity of the indicators 'abdominal discomfort' and 'defecation disorder', as well as the history of the disease and the preservation of the urge to defecate, the incidence of independent stools and the incidence of defecation without the use of enemas and laxatives, the severity of constipation according to the modified Wexner scale were evaluated on a point scale. Among the objective diagnostic methods, the analysis included the results of barium enema, transit of barium through the gastrointestinal tract (GI tract), X-ray defecography and reservoir function of the rectum. The following indicators of these diagnostic tests were used:

- Barium enema (n = 151)
  - Rectal width;
  - Length of the sigmoid colon;
  - Width of the sigmoid colon;
  - Width of the transverse colon;
  - Width of the ascending colon.

The analysis took into account the maximal transverse size of the each part of the large intestine. It should be noted that due to the retrospective nature of the analysis, as well as the technical difficulties of contrasting the hepatic flexure of the colon in patients with megacolon, and the imposition of intestinal loops, it was not possible in all cases to measure the length of the sigmoid colon and the width of the transverse and ascending colon.

- X-ray defecography with barium (n = 76)
  - Residual volume ($V_{res.}$);
  - Emptying time ($T_{def.}$).

For technical reasons, the emptying time during defecography was recorded in 68 of 76 patients who underwent this study.

Transit of barium through the gastrointestinal tract for 5 days (n = 87). In the statistical analysis, the severity of transit disorders was estimated in points (Table 2). In addition, the presence or absence of distal delay, that is, predominant contrast delay in the sigmoid and rectum, was taken into account.

- Reservoir function of the rectum (n = 125)
  - First sensitivity threshold (1 ST, ml);
  - Maximal tolerable volume (MTV, ml);
  - Index of the maximal tolerable volume (I_{MTV}, ml/mmHg) — the ratio of the maximal tolerable volume to the amount of residual rectal pressure created by it;
  - Coefficient of adaptation ($\Delta V/\Delta P$, ml/mmHg) — the ratio of volume increase to the increase in residual pressure from the threshold of sensitivity to the maximal tolerable volume.

In 62 patients, when examining the reservoir function of the rectum, only the volumes of air injected into the rectal balloon corresponding to the sensitivity thresholds were recorded, without taking into account the residual rectal pressure created by them. Therefore, it was impossible to calculate the index of the maximal tolerable volume and the coefficient of adaptation. In 9 more cases, it was not possible to calculate the adaptation coefficient due to the fact that patients were unable to differentiate the first threshold of sensitivity of the rectum to filling.

STATISTICAL ANALYSIS

Statistical analysis was performed using the Statistica software version 13.3 (TIBCO, USA). Considering the distribution different from the normal one for most features, the data were represented by medians with the 1st and 3rd quartiles. The univariate analysis was performed by comparing groups of patients with and without volvulus according to binary characteristics using the two–sided Fisher exact test, and according to rank (score) using the Mann–Whitney U-test. The multivariate analysis was performed using multiple logistic regression, where the dependent variable

Table 3. *Treatment of sigmoid volvulus in the anamnesis*

Method of treatment of volvulus	Number of observations, *n* = 47
Laparotomy, volvulus detorsion	14
Laparotomy, volvulus detorsion, mesosigmoplication	6
Endoscopic detorsion	10
Laparotomy, detorsion and endoscopic detorsion (in case of recurrent volvulus)	5
Conservative treatment	12

Table 4. *Clinical picture — comparison by binary signs (two-sided Fisher exact test)*

Feature \ Volvulus	Yes	No	*p*
Gender (males)	23 (48.9%)	61 (58.7%)	0.29
Constipation	36 (81.8%)	89 (90.8%)	0.16
Independent stool	39 (90.7%)	72 (80.0%)	0.14
Soiling	**11 (23.4%)**	**49 (49.5%)**	**0.004**

was the binary variable 'volvulus development'. The differences were recognized as statistically significant at $p < 0.05$. The nomogram was built using the RMSR-Studio library version 4.3.1.

RESULTS

The age of the general group of patients was 24.0 (18.0; 41.0) years. There were 84 men (55.6%) and 67 women (44.4%).

In 47 (31.1%) of 151 patients with idiopathic megacolon/megarectum, sigmoid colon volvulus occurred in the past or were detected upon admission or during checkup. In more than half of the patients — in 25 (53.2%) cases, the treatment of volvulus was previously carried out by detorsion by laparotomy, in some cases in combination with mesosigmoplication. Endoscopic detorsion was performed in 15 (31.9%) cases.

At the same time, in 5 patients with recurrent volvulus, it was performed both endoscopically and through laparotomy. Conservative methods were used to cure the volvulus in 12 (25.5%) patients (Table 3). Recurrence of the volvulus after its successful detorsion in one way or another occurred in 26 (55.3%) cases.

Among patients with volvulus, the proportion of men was slightly lower — 48.9% and 58.7%, respectively, but the difference was insignificant (Table 4). At the same time, patients with volvulus were significantly older — their mean age was 34.0 years, whereas in the group without volvulus this indicator was 21.0 years, $p < 0.0001$ (Table 5). There were no significant differences in the incidence of chronic constipation in 81.8% of patients with volvulus and 90.8% of patients without it, the preserved possibility of independent defecation, the intensity of abdominal distension, and the severity of the indicator 'abdominal discomfort' among patients with and without volvulus (Table 4, 5). In patients with volvulus, the incidence of defecation without the use of laxatives and enemas was significantly higher, and the severity of the 'defecation disorder' indicator and the intensity of constipation as per the Wexner scale were significantly lower (Table 5). The incidence of anal incontinence (soiling) in the group of patients with volvulus was also significantly lower (Table 4).

The median length of the sigmoid colon according to the barium enema data in patients with volvulus was significantly greater than without it and amounted to 80.0 cm and 62.0 cm, respectively ($p < 0.001$). The width of the sigmoid colon in the presence of a history of volvulus was also significantly larger (median values 11.5 cm vs. 9.0 cm, $p < 0.0001$), but the width of the rectum, on the contrary, was significantly smaller (median values 8.6 cm vs. 10.5 cm, $p < 0.0001$). There were no significant differences in the width of the transverse and ascending colon between the groups. Similarly, patients with and without volvulus did

Table 5. *Clinical picture: quantitative characteristics (Mann-Whitney U-test)*

Feature \ Volvulus	Yes (Me (Q1;Q3))	No (Me (Q1;Q3))	*n*	*p*
Age, years	**34.0 (23.5;49.0)**	**21.0 (18.0; 35.0)**	**151**	**< 0.0001**
Independent stool, points	3.0 (2.0; 4.0)	2.0 (1.0; 4.0)	116	0.242
Bloating, points	3.0 (2.0; 3.0)	3.0 (2.0; 4.0)	98	0.357
Defecation rate, points	**5.0 (3.0; 5.0)**	**3.0 (2.0; 4.0)**	**117**	**< 0.0001**
Urge to defecate, points	2.0 (1.0; 3.0)	2.0 (1.0; 3.0)	107	0.384
'Abdominal discomfort', points	10.0 (7.0; 14.0)	12.0 (7.0; 16.0)	97	0.126
'Defecation disorder', points	**5.0 (3.0; 8.0)**	**9.5 (6.0; 13.0)**	**96**	**< 0.0001**
Duration of symptoms, points	3.0 (2.0; 5.0)	4.0 (3.0; 4.0)	133	0.426
Constipation intensity (Wexner scale), points	**9.0 (7.0; 13.0)**	**14.0 (10.0; 18.0)**	**95**	**< 0.0001**

Table 6. *Results of diagnostic tests: rank characteristics (Mann-Whitney U-test)*

Feature \ Volvulus		Yes (Me (Q1;Q3))	No (Me (Q1;Q3))	*n*	*p*
Irrigoscopy	Length of the sigmoid colon, cm	**80.0 (70.0; 85.0)**	**62.0 (60.0; 75.0)**	**78**	**0.001**
	Width of the rectum, cm	**8.6 (7.0; 10.0)**	**10.5 (10.0; 12.0)**	**111**	**0.000**
	Width of the sigmoid colon, cm	**11.5 (10.0; 13.7)**	**10.5 (10.0; 12.0)**	**99**	**0.000**
	Width of the transverse colon, cm	7.1 (5.8; 11.0)	7.7 (6.0; 9.5)	40	0.925
	Width of the ascending colon, cm	7.5 (5.8; 9.2)	7.5 (6.5; 9.0)	29	0.647
GI transit time, points		5.0 (4.0; 5.0)	5.0 (4.0; 5.0)	87	0.557
Defecography	T_{def}, sec.	39.0 (27.5; 70.0)	60.0 (30.0; 70.0)	68	0.570
	V_{rec},ml	35.0 (20.0; 60.0)	50.0 (25.0; 85.0)	76	0.146
Reservoir function of the rectum	1 ST, ml	102.0 (40.0; 109.0)	102.0 (80.0; 105.0)	125	0.316
	MTV, ml	575.0 (210.0; 700.0)	750.0 (500.0;940.0)	81	0.060
	I_{MTV}, ml/mmHg	27.3 (17.6; 48.1)	32.5 (20.2; 55.0)	63	0.690
	$\Delta V/\Delta P$ ml/mmHg	44.7 (29.7; 84.1)	38.9 (20.9; 73.6)	54	0.470

Table 7. *Results of diagnostic tests: binary features (two-sided Fisher exact test)*

Feature \ Volvulus	Yes	No	*p*
Distal contrast delay in the GI transit time test	**1 (3.0%)**	**22 (53.7%)**	**0.001**

not demonstrate significant differences in the total transit time through the gastrointestinal tract, defecography results and indicators of reservoir function of the rectum (Table 6). The only parameter of the study of GI transit time where the difference was noticeable was the incidence of distal contrast delay, which in patients with volvulus was significantly less. Thus, in the presence of volvulus, distal delay occurred in only 1 (3.0%) follow-up, while in patients without volvulus it was recorded in more than half of the cases (Table 7).

The features that demonstrated a significant association with the incidence of volvulus were included in the multivariate analysis performed by multiple logistic regression, where the binary variable 'volvulus development' was dependent.

The best characteristics in statistical significance and prognostic ability were found in the model, which included only the size of the intestines according to the barium enema — the length and width of the sigmoid colon, and the width of the rectum. For this model, the Somers delta was 0.867, and the Kolmogorov-Smirnov statistics was 0.718, at $p < 0.0001$, which indicates a good classification ability of the model. At the same time, only the width of the sigmoid colon and the width of the rectum were significant independent variables. The odds ratio for the width of the rectum was 0.39 (CI 0.22–0.72), for the width of the sigmoid colon — 2.29 (CI 1.38–3.82) (Table 8).

Figure 1 shows the ROC curve for this function. According to the ROC analysis, the area under the curve was 0.93 ± 0.03 (CI 0.87–1.0), $p < 0.001$. The

Table 8. *Multiple logistic regression of predicting of sigmoid volvulus*

Feature	OR	95% Coincidence Interval		*p*
		Lower margin	Upper margin	
Length of the sigmoid colon	1.01	0.94	1.09	0.7440
Width of the rectum	**0.39**	0.22	0.72	**0.0023**
Width of the sigmoid colon	**2.29**	1.38	3.82	**0.0014**
Somers' D — 0.867, KS statistics — 0.718, $p < 0.0001$				

Yudin criterion determined a cut-off point 0.719, at which the sensitivity of the model was 82.4%, and the specificity was 89.5%.

Using this model, a nomogram was constructed to predict the risk of sigmoid colon volvulus in patients with idiopathic megacolon/megarectum by the size of the rectum and sigmoid colon (Fig. 2).

DISCUSSION

Among the factors predisposing to the volvulus, chronic constipation, frequent use of laxatives, a fiber diet are most often mentioned in the literature, which is typical for such 'endemic' areas of volvulus as Africa, Central Asia and India, elderly and senile age in Western countries, especially in combination with diabetes mellitus and neuropsychiatric diseases, potentially leading to impaired autonomic innervation and limited mobility of patients, as well as anatomical features of the large intestine [10,19]. The latter usually include an elongation of the sigmoid colon in combination with a narrowed base of its mesentery, as well as a megacolon [2,20]. An indirect confirmation of the increased risk of volvulus in patients with idiopathic megacolon is our own experience, in particular, the fact that volvulus occurred in more than 30% of patients in this study. And this is despite the fact that we did not include in the analysis patients who had bowel resections with colostomy before going to the clinic, most often just about the volvulus. It is the volvulus that is the main manifestation of the complicated course of megacolons and, accordingly, an indication for elective surgical treatment. But megacolon is not always complicated by volvulus, and recently the main feature that we focus on in assessing the risk is the presence of a history of volvulus. Therefore,

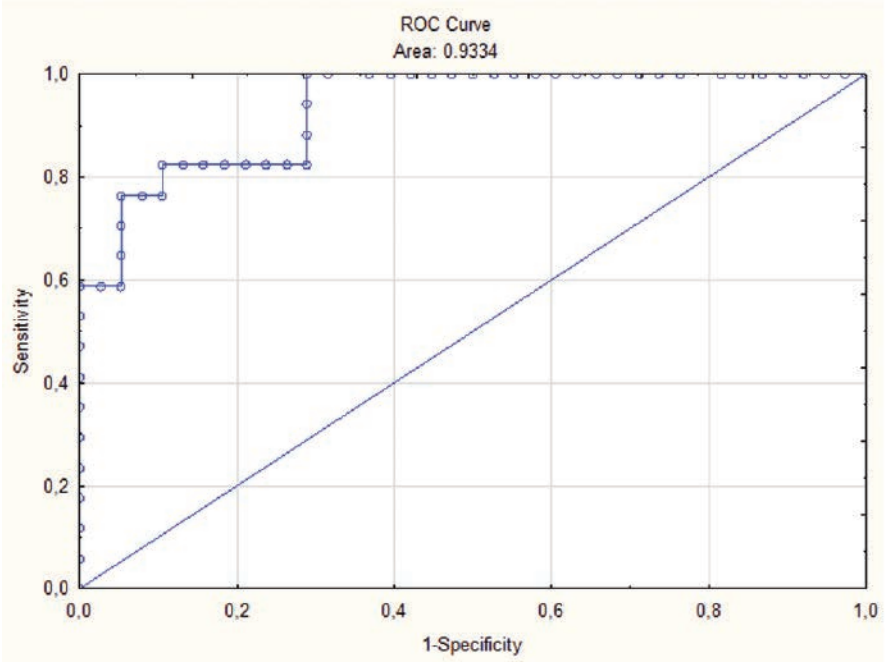

Figure 1. *ROC curve of the sigmoid colon inversion prediction model*

it seemed appropriate to us to try to identify additional risk factors that could be used in choosing megacolon/megarectum treatment tactics even before the complication develops. With regard to the gender and age characteristics of patients with volvulus, a significant (2–4-fold) predominance of men over women has been described in the literature [1,8, 10]. In the presence of megacolons, we could not detect significant differences in gender in patients with and without volvulus. Patients with a history of volvulus were significantly older. But at the same time, their average age was only 34 years, which, in general, is typical for the 'endemic' countries of the world, unlike the USA and Western Europe, where volvulus is more common in elderly patients.

As for the clinical picture, the majority of patients with idiopathic megacolon, both with and without volvulus, complained of constipation, which corresponds to the literature data. Nevertheless, the possibility of independent defecation, at least periodically, persisted in most of them and we did not find significant differences in this feature between the groups. There were also no statistically significant differences either in the intensity of bloating in particular, or in the severity of abdominal discomfort in general. Moreover, patients with a history of volvulus were characterized by a significantly higher incidence of defecation and a lower severity of the 'defecation disorder' indicator. The intensity of constipation as per the Wexner scale in patients with volvulus was also statistically significantly lower.

In relation to diagnostic tests, according to the univariate analysis, the risk of volvulus was significantly associated with the size of the rectum and sigmoid colon according to barium enema. Moreover, the length and width of the sigmoid colon directly correlated with the volvulus incidence, and the width of the rectum was inversely proportional. As for the results of the other diagnostic tests — the total transit time through the gastrointestinal tract, the parameters of defecography and the study of the reservoir function of the rectum, we could not find significant

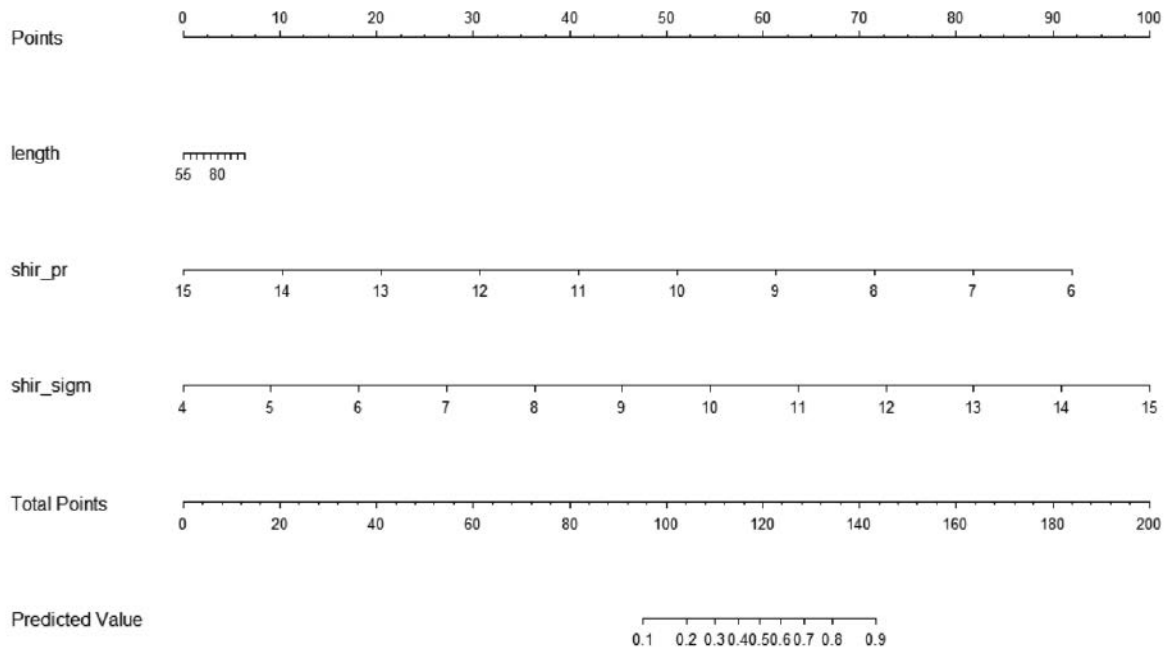

Figure 2. *Nomogram predicting the risk of sigmoid volvulus in patients with idiopathic megacolon/megarectum by the size of the rectum and sigmoid colon.*

differences between patients with and without volvulus. The only exception was the incidence of distal contrast delay according to the passage of barium suspension in the gastrointestinal tract, which was significantly lower in patients with volvulus. Along with a lower incidence of complaints of anal incontinence (leakage) and a lower severity of symptoms of defecation disorder, this reflects a lower risk of volvulus in patients with idiopathic megarectum and is consistent with the results of the barium enema.

We intentionally did not include such a feature as the width of the base of the mesentery of the sigmoid colon in the analysis, since it is very difficult to assess it using diagnostic tests, and our purpose was to try to determine the risk factors for volvulus at the preoperative stage. According to the multivariate logistic regression analysis, the independent predictors significantly associated with the risk of volvulus were the width of the sigmoid colon and rectum. At the same time, the best characteristics in terms of statistical significance and prognostic ability were found in the model, which included only the size of the intestines according to the barium enema — the length and width of the sigmoid colon and the width of the rectum. Removing the sigmoid colon length parameter or adding clinical and other diagnostic features only worsened the qualitative characteristics. And for this model, according to the ROC analysis, good parameters were obtained — with high statistical significance, the area under the curve was 0.93, and sensitivity and specificity were 82.4% and 89.5%, respectively. Therefore, using this model, a nomogram was constructed to predict the risk of sigmoid colon volvulus in patients with idiopathic megacolon/megarectum by the size of the rectum and sigmoid colon (Fig. 2).

The most general conclusions that can be drawn based on the nomogram are as follows: with a score of more than 144, the risk of volvulus is more than 90%. At the same time, the normal dimensions of the rectum and sigmoid colon, that is, the rectum is no more than 8.5 cm and the sigmoid is no wider than 6 cm, are associated with the risk of volvulus in less than 10% of cases. If there is no megarectum, but the width of the sigmoid colon is more than 12 cm, then the probability of volvulus exceeds 90%. At the same time, with a significant megarectum, when the transverse size of the rectum is more than 11 cm, the risk of volvulus is less than 90% for any size of the sigmoid colon. Finally, when the width of the rectum is less than 11 cm, and the sigmoid is more than 9.7 cm, various combinations are possible with a probability of volvulus of more than 90%, which can be considered as an indication for surgery in the absence of a history of volvulus. The disadvantage of the proposed nomogram is, of course, its construction based on a retrospective analysis and the impossibility of strict validation in a large number of patients due to the rarity of the condition itself — megacolon. Therefore, we intentionally suggest using a strict criterion for choosing treatment– the probability of volvulus is more than 90%. On the other hand, the potential severity of complications of volvulus allows, in our opinion, to use this criterion in determining indications for elective surgical treatment of patients with idiopathic megacolon. The use of this nomogram is also convenient because it takes into account only the data of irrigoscopy, which in any case is advisable for persons with suspected megacolon, and the main importance in it is the size of the rectum and sigmoid colon, which are easy to measure in almost all patients.

CONCLUSION

Idiopathic megacolon is associated with an increased risk of developing sigmoid colon volvulus. At the same time, according to the multivariate logistic regression analysis, the width of the rectum and sigmoid colon are of the greatest importance from the point of view of assessing the risk of volvulus. The risk of volvulus of more than 90%, estimated according to the proposed nomogram, can be considered as an indication for elective surgery in patients with idiopathic megacolon in the absence of a history of volvulus.

AUTHORS CONTRUBUTION

Concept and design of the study: *Denis V. Aleshin, Sergey I. Achkasov*
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