ORIGINAL ARTICLE

A new model for prediction of bowel gangrene in sigmoid volvulus

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ABSTRACT

BACKGROUND: Sigmoid volvulus is a pathology that can be mortal because it is frequently encountered in elderly patients. In case of bowel gangrene, mortality and morbidity increase further. We planned a retrospective study, in which the effectiveness of the model was evaluated by creating a model that aims to predict whether intestinal gangrene is present in patients with sigmoid volvulus only by blood tests and thus to quickly guide treatment methods.

METHODS: In addition to demographic data such as age and gender, laboratory values such as white blood cell, C-reactive protein (CRP), lactate dehydrogenase (LDH), potassium, and colonoscopic findings and whether there was gangrene in the colon during the operation were evaluated retrospectively. In the analysis of the data, independent risk factors were determined by univariate and multivariate logistic regression analyzes as well as Mann–Whitney U and Chi-square tests. Receiver operating characteristic (ROC) analysis was performed for statistically significant continuous numerical data, and cutoff values were determined and Malatya Volvulus Gangrene Model (MVGM) was created. The effectiveness of the created model was again evaluated by ROC analysis.

RESULTS: Of the 74 patients included in the study, 59 (79.7%) were male. The median age of the population was 74 (19–88), and gangrene was detected in 21 (28.37%) patients at surgery. In univariate analyzes, leukocytes <4000/mm^3 and >12000/mm^3 (OR: 10.737; CI 95%: 2.797–41.211, p=0.001), CRP ≥0.71 mg/dl (OR: 8.107 CI 95%: 2.520–26.082, p<0.0001), potassium ≥3.85 mmoL/L (OR: 3.889; 95% CI): 1.333–11.345, p=0.013), and LDH ≥288 U/L (OR: 3.889; CI 95%: 1.333–11.345, p=0.013), whereas, in multivariate analyzes, only CRP ≥0.71 mg/dL (OR: 3.965; CI 95%: 1.071–15.462, p=0.047) was found to be an independent risk factor for bowel gangrene. The strength of MVGM was AUC 0.836 (0.737–0.936). In addition, it was observed that the probability of bowel gangrene increased approximately 10 times if MVGM was ≥7 (OR: 9.846; 95% CI: 3.016–32.145, p<0.0001).

CONCLUSION: Besides being non-invasive compared to the colonoscopic procedure, MVGM is a useful method for detecting bowel gangrene. In addition, it will guide the clinician in taking the patients with intestinal loop gangrene to emergency surgery without wasting time in the treatment steps, as well as avoiding complications that may occur during colonoscopy. In this way, we think that morbidity and mortality rates can be reduced.

Keywords: Endoscopy; ischemia; model; sigmoid colon; treatment; volvulus.

INTRODUCTION

Sigmoid volvulus is an intestinal obstruction that needs to be treated urgently, which occurs as a result of rotation of the sigmoid colon around its mesentery. It is the most common cause of non-cancerous obstructions.[1,2] It is especially seen in the Middle East, Asian and African populations fed with a high fiber diet.[3] Chronic constipation and having a redundant colon are among the causes.[4] The incidence is higher in men. Since the population is elderly patients with accompanying comorbidities, the mortality of emergency surgical interventions is quite high.[5] Mortality increases further in patients

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who have been operated for bowel gangrene and perforation.[6] Although the treatment of patients with sigmoid volvulus is not yet an optimal approach, rapid colonoscopic detorsion, resuscitation, and surgery before discharge begins before the gangrenous processes of the colon begin. Bowel gangrene development rates due to sigmoid volvulus have been shown in the literature as 6.1–93.4%.[7–11] In addition, mortality rates are in the range of 0–40% in those without gangrene, and it can reach up to 3.7–80% in those with bowel gangrene.[7–14] Causes such as cardiovascular disease, increased number of rotations of the intestine, ileosigmoid knotting, and delayed admission to hospital have been shown in bowel gangrene.[6] Pregnancy ($p<0.05$), comorbid disease ($p<0.05$), presence of accompanying shock ($p<0.01$), and prolonged symptoms ($p<0.05$), which are the factors affecting the progression to bowel gangrene in sigmoid volvulus, showed a correlation between overrotation ($p<0.05$) and ileosigmoid knotting.[15] Although imaging methods such as Doppler ultrasonography, angiography, or scintigraphy can show vascular occlusions in determining whether there is bowel gangrene, intestinal viability is only demonstrated endoscopically.[16] Since colonoscopic detorsion is not recommended in the patient group with bowel gangrene, perforation, or acute abdomen findings, it should be operated urgently.[13] In the study, it was planned to create a model that would help the clinician to predict the onset of colonic gangrenous processes with laboratory findings, independent of the colonospic diagnosis, and to evaluate the effectiveness of the model.

MATERIALS AND METHODS

Study Design

In the study, which was planned retrospectively with the ethics committee of numbered 2022/2913, demographic data such as age and gender, laboratory values such as white blood cell (WBC), C-reactive protein (CRP), lactate dehydrogenase (LDH), potassium and colonoscopic findings and gangrene status of the colon in the operation were obtained of the patients who were operated on with the diagnosis of sigmoid volvulus. The data were divided into two groups according to the presence of gangrene in the bowel due to sigmoid volvulus. Independent risk factors were determined to predict gangrene by identifying those with colonic gangrene findings at colonoscopy and operation.

Management

Patients diagnosed with sigmoid volvulus by direct abdominal X-ray or computed tomography are treated with rapid nasogastric decompression, fluid resuscitation, and antibiotherapy followed by colonoscopic detorsion and operation without discharge, if there are no acute abdomen examination findings and no morbidity conditions. In the group of patients with high acute abdominal findings, surgery is performed following rapid resuscitation without trying colonoscopic detorsion.

Statistical Analysis and Model Formation

Compliance of numerical data with normal distribution was controlled by Kolmogorov–Smirnov test. It was determined that none of the variables showed a normal distribution. Continuous variables were analyzed with the Mann–Whitney U-test. The median, minimum, and maximum values of these variables were given. Chi-square analysis was performed for categorical variables. Frequency and percentage values of these variables were given. Receiver operating characteristic (ROC) analysis was performed by taking the variables with a statistically significant p value in similar variables. Cutoff values of ≥0.71 mg/dL, ≥288 U/L, and ≥3.85 mmol/L were found for CRP, LDH, and potassium values, respectively (Table 1). Univariate logistic regression analysis was performed for each variable. As a result of the analysis, Malatya Volvulus Gangrene Model (MVGM) was established by calculating five points for

Table 2. Malatya Volvulus Gangrene Model

MVGM		
WBC	<12000/mm³ and >4000/mm³	0 point
	>12000/mm³ and <4000/mm³	5 point
CRP (mg/dL)	<0.71	0 point
	≥0.71	4 point
LDH (U/L)	<288	0 point
	≥288	2 point
Potassium (mmol/L)	<3.85	0 point
	≥3.85	2 point

WBC: White blood cell; CRP: C-reactive protein; LDH: Low-density lipoprotein; MVGM: Malatya Volvulus Gangrene Model.

Table 1. Performance of ideal cut-off points for CRP, LDH, Potassium, and MVGM and its success over our sample

	Cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC	95% CI		p
CRP (mg/dL)	≥0.71	76.19	71.69	51.61	88.37	0.808	0.689	0.926	<0.0001
LDH (U/L)	≥288	66.66	66.03	43.75	83.33	0.725	0.587	0.868	0.002
Potassium (mmol/L)	≥3.85	66.66	66.03	43.75	83.33	0.725	0.587	0.868	0.002
MVGM	>7	71.42	79.24	57.69	87.50	0.836	0.737	0.936	<0.0001

PPV: Positive predictive value; NPV: Negative predictive value; AUC: Area under the curve; CI: Confidence interval; CRP: C-reactive protein; LDH: Low-density lipoprotein; MVGM: Malatya Volvulus Gangrene Model.

leukocytosis or leukopenia, four points for CRP ≥0.71 mg/dL, two points for LDH ≥288 U/L, and two points for potassium ≥3.85 mmoL/L (Table 2). The power of the model on bowel gangrene was calculated. Prospective selective multivariate logistic regression analysis was performed with the variables found to be statistically significant. The Hosmer–Lemeshow test was used to evaluate the goodness of fit. P<0.05 was considered statistically significant.

RESULTS

As a result of removing the missing data from 211 patients in our clinic, 59 (79.70%) of the remaining 74 patients were male and the median age of the patient population was 74 (19–88). The median age of 21 patients with bowel gangrene was 73 (19–84) and the median age of 53 patients without bowel gangrene was 71 (19–88). Although bowel gangrene was observed in 16 (27.10%) male patients and five (33.34%) female patients, there was no statistically significant difference in terms of bowel gangrene in gender and age (Table 3).

Endoscopy was performed in 25 of the patients included in the study. Twenty of them were operated electively without being discharged after endoscopic detorsion. In five of them,

Table 3. Table of continuous variables and categorical datae

	Bowel Gangrene						p
	Absent		Present		Total		
	n	% / Med (Min-Max)	n	% / Med (Min-Max)	n	% / Med (Min-Max)	
Gender							
Male	43	72.90	16	27.10	59	79.70	0.634
Female	10	66.66	5	33.34	15	20.30	
WBC							
Yes*	19	51.35	18	48.65	37	50.00	<0.0001
No	34	91.89	3	8.11	37	50.00	
CRP							
≥0.71 mg/dl	15	48.38	16	51.62	31	41.89	<0.0001
<0.71 mg/dl	38	88.37	5	11.63	43	58.11	
LDH							
≥288 U/L	18	56.25	14	43.75	32	43.24	0.01
<288 U/L	35	83.33	7	16.67	42	56.76	
Potassium							
≥3.85 mmol/L	18	56.25	14	43.75	32	43.24	0.01
<3.85 mmol/L	35	83.33	7	16.67	42	56.76	
MVGM							
≥7	11	42.30	15	57.70	26	35.14	<0.0001
<7	42	87.50	6	12.50	48	64.86	
Mortality							
Present	14	66.66	7	33.34	21	28.38	0.025
Absent	47	88.68	6	11.32	53	71.62	
Operation							
Resection+hartman	22	57.89	16	42.11	38	51.35	0.016
Resection anastomosis	23	82.14	5	17.86	28	37.84	
Ileosigmoid bypass	8	100	0	0	8	10.81	
Age	53	71 (19–88)	21	73 (19–84)	74	73 (19–88)	0.919
LDH (U/L)	53	253 (130–727)	21	381 (173–3325)	74	270.5 (130–3325)	0.002
CRP (mg/dL)	53	0.4 (0.28–5.07)	21	3.9 (0.32–24.9)	74	0.47 (0.28–24.9)	<0.0001
Potassium (mmol/L)	53	3.6 (2.2–5.04)	21	4.6 (2.7–8.15)	74	3.8 (2.2–8.15)	0.002

*WBC: <4000 mm³ ve >12000/mm³; Med: Median; Max: Maximum; Min: Minimum. P<0.05 was considered statistically significant. WBC: White blood cell; CRP: C-reactive protein; LDH: Low-density lipoprotein; MVGM: Malatya Volvulus Gangrene Model.

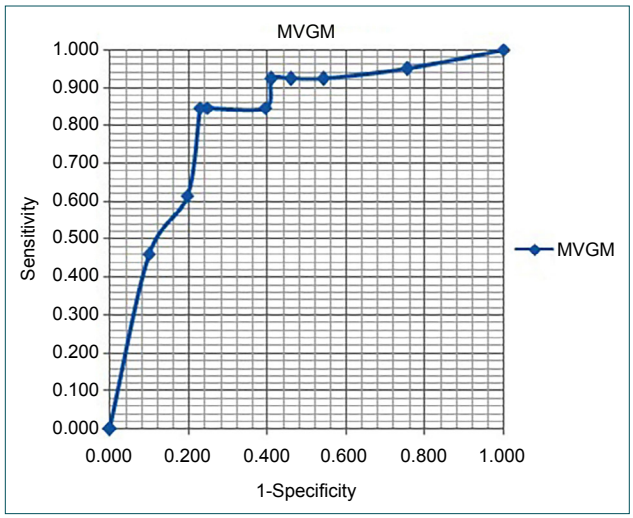

Figure 1. ROC curve of Malatya volvulus gangrene model to distinguish bowel gangrene.

bowel gangrene was detected and emergency operation was performed. Forty-nine patients with acute abdominal symptoms or suspected acute abdomen were operated on, and bowel gangrene was detected in 16.

Of the 74 patients, 20 of whom were semi-elective and 54 were operated urgently, 38 underwent sigmoid resection-Hartman end colostomy, 28 had sigmoid resection-end-to-end anastomosis, and eight had ileosigmoid bypass. Although the total mortality was 13 (17.57%) in 74 patients who were operated on, while seven (33.34%) of 21 patients with bowel gangrene were mortal and six (11.32%) of 53 patients without bowel gangrene were mortal (p=0.025). In the analysis of age, LDH, CRP, and potassium numerical variables, a statistically significant difference was found between LDH, CRP, and potassium and bowel gangrene (p=0.002, p<0.0001, and p=0.002). Separate cutoff values were calculated for these parameters; 16 (51.62%) of 31 patients with CRP ≥0.71 mg/dL, 14 (43.75%) of 32 patients with LDH ≥288 U/L, and 14 (43.75%) of 32 patients with potassium ≥3.85 mmol/L bowel gangrene was observed and a statistically significant difference was observed (p<0.0001, p=0.01, p= 0.01).

Bowel gangrene was observed in 18 (48.65%) of 37 patients with leukocytes >12000/mm^3 and <4000/mm^3, and the difference was statistically significant (p<0.0001). In univariate analysis, leukocytes (OR: 10.737; CI 95%: 2.797–41.211, p=0.001), CRP (OR:8.107 CI 95%: 2.520–26.082, p<0.0001), potassium (OR: 3.889; 95% CI): 1.333–11.345, p=0.013), and LDH (OR: 3.889; CI 95%: 1.333–11.345, p=0.013) odds ratios were calculated and a risk scale was created accordingly. The scores of the patients from the model were calculated by giving five points for leukocytosis or leukopenia, four points for CRP ≥0.71 mg/dL, two points for LDH ≥288 U/L, and two points for potassium ≥3.85 mmoL/L. According to the model, the median score of the patients was 11 (2–13) in those with bowel gangrene and 2 (0–13) in those without bowel gangrene. With ROC analysis, the power of the model to predict bowel gangrene was found to be AUC 0.836 (0.737–0.936) (Fig. 1). Cutoff value was found to be seven and above. There was a statistically significant difference between patients with MVGM score of seven and above and bowel gangrene (OR: 9.846; 95% CI: 3.016–32.145, p<0.0001). In multivariate analyzes, CRP (OR: 3.965; CI 95%: 1.071–15.462, p=0.047) was found to be an independent risk factor for bowel gangrene (Table 4).

DISCUSSION

In our study, in univariate analyzes, leukocytes >12000/mm^3 ve <4000/mm^3 (OR: 10.737; CI 95%: 2.797–41.211, p=0.001), CRP ≥0.71 mg/dL (OR: 8.107 CI 95%: 2.520–26.082, p<0.0001), and potassium ≥3.85 mmoL/L (OR: 3.889; CI), while a statistically significant difference was found between 95%: 1.333–11.345, p=0.013) and LDH ≥288 U/L (OR: 3.889; CI 95%: 1.333–11.345, p=0.013) and bowel gangrene, only the CRP value was ≥0.71 mg/dL as a result of multivariate analyses has been shown to be an independent risk factor for bowel gangrene. Non-vascular bowel gangrene occurs due to sigmoid volvulus. It is expected that there will be an increase in

Table 4. Univariate and multivariate logistic regression analysis results

	Univariate Logistic Regression			Multivariate Logistic Regression		
	OR	95% CI	p	OR	95% CI	p
WBC						
<4000/mm^3 and >12000/mm^3	10.737	2.797–41.211	0.001	4.326	0.959–19.507	0.057
CRP (mg/dL)						
≥0.71	8.107	2.520–26.082	<0.0001	3.965	1.071–15.462	0.047
LDH (U/L)						
≥288	3.889	1.333–11.345	0.013	1.664	0.454–6.097	0.443
Potassium (mmol/L)						
≥3.85	3.889	1.333–11.345	0.013	2.492	0.706–8.794	0.156

WBC: White blood cell; CRP: C-reactive protein; LDH: Low-density lipoprotein; OR: Odds ratio CI: Confidence interval. P<0.05 was considered statistically significant.

intracellular enzymes, intracellular electrolytes, and inflammatory cells and markers due to necrosis in the bowel tissue. The increase in LDH, potassium and CRP, as well as the reasons for the increase or decrease in the amount of leukocytes, are thought to be related to this, and this is supported by studies in the literature. Matsumoto et al.[17] showed that LDH and CRP were statistically significant as in our study, which is one of the biochemical markers investigated for vascular and non-vascular bowel ischemia ($p<0.01$). However, no statistically significant difference was found for WBC. In the intestinal ischemia model performed by Acosta on pigs, it was shown that LDH was found to be significantly higher in peritoneal fluid, although not in plasma ($p=0.003$).[18] In the ischemia model performed by Zhang et al.[19] on rabbits, it was shown that LDH increased in plasma and became a significant biochemical marker ($p=0.01$). Although predictive factors of bowel gangrene in sigmoid volvulus have been revealed in the literature, a bowel gangrene model has not been established using biochemical markers. However, there are models that help in the progression of the disease using imaging methods. One of them is the AXIS classification. In this classification, it is thought that it can determine the severity of sigmoid volvulus in the early stage according to the rotational movement of the sigmoid colon on direct X-ray and may help clinicians about the course of treatment.[20] The power of the model created in our study in detecting bowel gangrene was AUC 0.836 (0.737–0.936). The incidence of bowel gangrene increases 10 times in patients with a score of 7 or higher in MVGM. We have started to use this model in our clinical patient management, and it may provide clinicians with an idea to operate patients without acute abdomen symptoms but with bowel gangrene without wasting time with colonoscopic detorsion. However, the necessity of evaluating the model prospectively in larger patient groups is one of the shortcomings of the study.

Conclusion

In addition to being a practical method for detecting bowel gangrene, MVGM will help clinicians in the operation of patients with simple biochemical markers in the blood, without wasting time with an invasive and morbid procedure such as colonoscopic detorsion, which is one of the treatment steps of patients.

Ethics Committee Approval: This study was approved by the İnönü University Non-interventional Clinical Research Ethics Committee (Date: 08.02.2022, Decision No: 2022/2913).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: C.C.; Design: C.C., Ö.G.; Supervision: C.A.; Resource: E.C.; Materials: H.K.; Data: N.T.B.; Analysis: C.C.; Literature search: C.C., K.S.; Writing: C.C., Y.S.A.; Critical revision: C.C., M.G.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Sigmoid volvulus'ta bağırsak gangreninin tahmininde yeni bir model

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AMAÇ: Sigmoid volvulus yaşlı hastalarda sık görülmesi nedeniyle mortal seyreden bir patolojidir. Bağırsak gangreni durumunda mortalite ve morbidite daha da artmaktadır. Sigmoid volvuluslu hastalarda bağırsak gangreni olup olmadığını sadece kan tahlileri ile tahmin etmeyi ve böylece tedavi yöntemlerine hızlı bir şekilde rehberlik etmeyi amaçlayan bir model oluşturarak modelin etkinliğinin değerlendirildiği geriye dönük bir çalışma planladık.

GEREÇ VE YÖNTEM: Kliniğimizde 1999–2021 tarihleri arasında sigmoid volvulus nedeniyle opere edilen hastaların yaş, cinsiyet gibi demografik verilerinin yanında white blood cell (WBC), C-reaktif protein (CRP), LDH, potasyum gibi labaratuar değerleri, kolonoskopik bulgulara ve operasyonda kolonda gangren olup olmadığı geriye dönük olarak incelendi. Verilerin analizinde Mann-Whitney U ve ki-kare testlerinin yanısıra Univariate ve Multivariate Logistic Regresyon analizleri ile bağımsız risk faktörü belirlendi. İstatistiksel olarak anlamlı olan sürekli sayısal veriler için ROC analizi yapılarak cut off değerleri belirlendi ve Malatya Volvulus Gangren Modeli (MVGM) oluşturuldu. Oluşturulan modelin etkinliği yine ROC analizi ile değerlendirildi.

BULGULAR: Çalışmaya alınan 74 hastanın 59'u (%79.7) erkekti. Popülasyonun ortanca yaşı 74 (19–88) olmasının yanısıra ameliyatta 21 (%28.37) hastada gangren tespit edildi. Tek değişkenli analizlerde lökositler <4000/mm^3 ve >12000/mm^3 (OR: 10.737; CI %95: 2.797–41.211, p=0.001), CRP ≥0.71 mg/dl (OR: 8.107 CI %95: 2.520–26.082, p<0.0001), potasyum ≥3.85 mmol/L (OR: 3.889; %95 GA): 1.333–11.345, p=0.013) ve LDH ≥288 U/L (OR: 3.889; CI %95: 1.333–11.345, p=0.013), çok değişkenli analizlerde ise sadece CRP ≥0.71 mg/dl (OR: 3.965; CI %95: 1.071–15.462), p=0.047) bağırsak gangreni için bağımsız bir risk faktörü olarak bulundu. MVGM'nin gücü AUC 0.836 (0.737–0.936) idi. Ayrıca MVGM ≥7 ise (OR: 9.846; %95 GA: 3.016–32.145, p<0.0001) bağırsak kangreni olasılığının yaklaşık 10 kat arttığı gözlendi.

TARTIŞMA: Kolonoskopik işleme kıyasla noninvaziv olmasının yanında MVGM, bağırsak gangrenini tespit etmede kullanışlı bir yöntemdir. Ayrıca bağırsak ansı gangrene giden hastaların tedavi basamaklarında vakit kaybetmeden acil ameliyata alınmasında klinisyeni yönlendirmekle birlikte kolonoskopi esnasında meydana gelebilecek komplikasyonlardan da uzak durulmasını sağlayacaktır. Bu sayede morbidite ve mortalite oranlarının azaltılabileceğini düşünmekteyiz.

Anahtar sözcükler: Endoskopi; iskemi; model; sigmoid kolon; tedavi, volvulus.

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