

A new prognostic marker in patients undergoing Hartmann's procedure for acute tumoral obstruction of the left colon

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ABSTRACT

BACKGROUND: In acute obstructive left-sided colorectal cancers (AOLCRC), damage to the colon wall may occur as a result of distension of the colon segments proximal to the tumor. In this study, we aimed to evaluate the relationship between the ratio of dilated colon diameter (CD) to lumbar vertebral corpus diameter on preoperative abdominal computed tomography (CT) scan in patients undergoing Hartmann's Procedure (HP) and post-operative complications.

METHODS: The tumor group consisted of 49 patients who underwent HP for AOLCRC under emergency conditions. The control group consisted of 49 age- and gender-matched individuals (compatible with tumor group) that had an abdominal CT due to pathologies outside the gastrointestinal tract and without a history of abdominal surgery. In both groups, the ratios of the CD to the diameter of the first lumbar vertebra corpus (LI-VD) measured on axial CT images of each patient. These ratios were compared between groups. In the tumor group, the relationship between post-operative complications (Clavien-Dindo classification-major (grade \geq III), minor (grade <III)) and demographic characteristics, pre-operative biochemical values, comorbid diseases, tumor pathological stage, operation time, and colon segments' CD/LI-VD ratios was evaluated.

RESULTS: The CD/LI-VD ratio in the tumor group was significantly higher than that of the control group ($p < 0.001$). An increase in the pre-operative transverse and descending colon CD/LI-VD ratios in the tumor group were found to be a prognostic parameter for the development of major post-operative complications ($p < 0.001$ and $p = 0.015$, respectively), with the cut-off values as 1.52 and 1.21 ($p = 0.013$ and $p = 0.042$), respectively. The increase in the pre-operative transverse colon CD/LI-VD ratio was also associated with the increase in the blood urea level ($p = 0.044$). A positive correlation was observed between the pre-operative blood urea levels and post-operative complications ($p = 0.015$).

CONCLUSION: Pre-operative transverse and descending colon CD/LI-VD ratios in AOLCRC are promising prognostic parameters for major postoperative complications.

Keywords: Acute abdomen; colon tumor; Hartmann's procedure; ileus, Laplace's law; obstructive left-sided colorectal cancer.

INTRODUCTION

Acute intestinal obstruction develops in 7–29% of colorectal cancers.^[1] More than 75% of large bowel obstructions oc-

cur in tumors distal to the splenic flexure. Acute bowel obstruction is one of the most common causes of emergency

Cite this article as: Kayapınar AK, Çalık B, Şahin H, Tuncer K, Baş K, Engin Ö, et al. A new prognostic marker in patients undergoing Hartmann's procedure for acute tumoral obstruction of the left colon. *Ulus Travma Acil Cerrahi Derg* 2022;28:1248-1257.

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Ulus Travma Acil Cerrahi Derg 2022;28(9):1248-1257 DOI: 10.14744/tjtes.2021.67792 Submitted: 26.01.2021 Accepted: 22.06.2021

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surgery.^[2,3] In this patient group, clinical status worsens as a result of bacterial overgrowth in the colon lumen, bacterial translocation from bowel into the peritoneal cavity, and fluid and electrolyte imbalance. In addition, muscle rupture and microperforation may occur in the colon wall due to excessive distension of the colon. A delay in management and treatment may result in serious morbidity and mortality.^[3-5] Therefore, emergency intervention (surgery or bridging treatment) becomes crucial.

In acute obstruction of right colon tumors, after the resection of dilated colon segment, an anastomosis (ileo-colic) is usually performed between bowel segments with normal diameter and intact blood supply.^[3] However, in acute obstructive left-sided colorectal cancers (AOLCRC), the choice between multiple surgical intervention or palliative method is still controversial.^[3,6] Tumor resection with colonic anastomosis is one of the preferred methods in this group of patients.^[3] However, in the colon-colonic anastomosis, which is made between the colon with a damaged wall structure due to dilatation and the colon with normal wall structure, can lead to a higher risk of leakage compared to ileo-colic anastomosis.^[4,5,7,8] Hartmann's Procedure (HP) is another method generally preferred in the treatment of AOLCRC because it does not require complicated surgery and an anastomosis.^[9,10] However, the post-operative complication rate of HP is not low.^[11,12]

Chao et al.^[13] used the ratio of colon diameter (CD) to 1st lumbar vertebral corpus diameter (LI-VD) to determine the relationship between colon perforation and colon dilatation rate in pediatric patients with perforation due to toxic megacolon. Zvizdic et al.^[14] used a similar ratio for early diagnosis of necrotizing enterocolitis in premature infants. In an experimental model, the ratio of CD to vertebral corpus length in cats with normal and megacolon was compared and this ratio was determined as a good indicator for the diagnosis of megacolon.^[15]

Although these studies were not conducted on the same subject as our study, they can constitute a step in standardizing the CD measurements. At present, there are no studies in the literature that used CD/LI-VD ratio to predict colon wall damage in adults.

Our aim in this study was to determine the relationship of colon CD/LI-VD ratio with post-operative complications in patients who underwent HP for AOLCRC under emergency conditions.

MATERIALS AND METHODS

Ethical Consideration

This study was approved by the institutional ethics committee (Date: 13.07.2017, decision number: 26) with the need for informed consent for data analysis waived.

Patients and Study Design

Patient Groups

The clinical data of 76 patients who underwent emergency HP due to AOLCRC between the years 2007 and 2017 were retrospectively analyzed.

Fourteen patients with intraoperative perforation, septic, and unstable hemodynamic conditions, ten patients whose abdominal computed tomography (CT) were not done within the past 48 h preoperatively, and three patients that had intraoperative diagnosis of peritoneal carcinomatosis were excluded from the study. There were two patient groups in the study cohort.

1. Tumor group, which included 49 patients with abdominal distension who could not expel gas in the past 24 h, and underwent HP due to a tumor that had completely obstructed the left colon on abdominal CT.
2. The control group (49) is composed of individuals with the following specified characteristics:
 - a. Cases that were age- and gender-matched to the cases in the tumor group
 - b. Cases that have undergone abdominal CT due to pathologies other than gastrointestinal system
 - c. Cases without history of abdominal surgery.

Abdominal CT images of the control group were obtained from the radiological database of the hospital.

The control group was formed for two purposes;

1. To determine whether the colon segment CD/LI-VD ratios of the patients in the tumor group were different from those of controls
2. To evaluate the colon CD/LI-VD ratio in adults, because it has not been investigated so far.

Evaluation of Abdominal CT Scan in Groups

The measurements from abdominal CT scans were done by the same radiologist who had 10 years of experience in abdominal imaging.

All study participants' largest diameters of all colon segments (cecum, ascending, transverse and descending colon) proximal to the tumor were recorded. The transverse diameter of the first lumbar vertebral corpus at the level of transverse processes was measured. Then the ratio of the widest CD to the vertebral corpus diameter (CD/LI-VD) was determined for each case (Fig. 1). Correlations between these ratios and the Clavien-Dindo grades were evaluated.

In addition, in the tumor group, subcutaneous fat thickness at the umbilicus level was also measured in each patient.

Data Collection

The patients' electronic health records were reviewed from

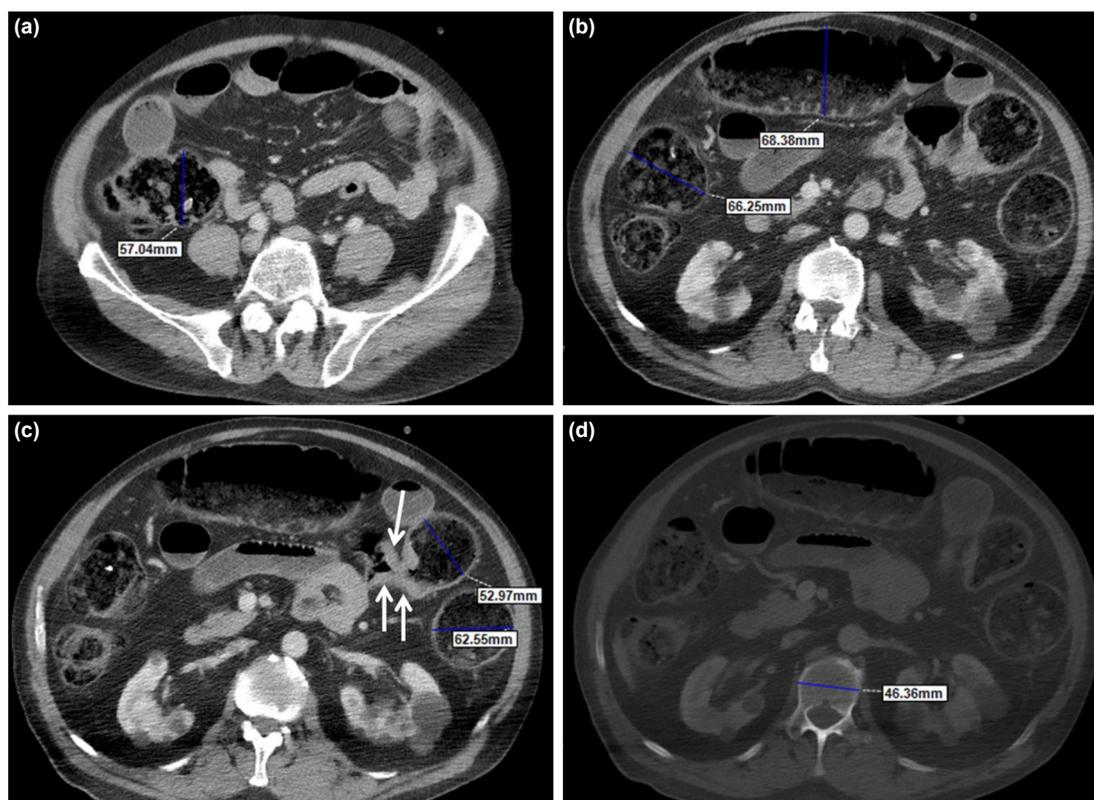


Figure 1. Demonstration of measurement of colon segments and L1 vertebral body diameter in axial CT scan of a 70-year-old man with large bowel obstruction due to sigmoid tumor. Transverse diameters perpendicular to longitudinal axis of cecum (a), ascending colon and transverse colon (b), descending colon and sigmoid colon proximal to the tumor (c) were measured. Sigmoid colon tumor is seen as a concentric irregular thickening of the of the bowel wall (arrows in c). Note that, due to the luminal obstruction, dilatation of the colonic segments and retention of fecaloid material in the lumen can be seen. For standardization of the measurements, axial largest diameter of the first lumbar vertebra where transverse processes are seen was measured (d), and the ratio of each colonic transverse diameter to the vertebral corpus diameter (CD/L1-VD) was determined for each colon segments.

the hospital records and laboratory variables (e.g., blood urea (mg/dL), creatinine (mg/dL), aspartate aminotransferase (U/L), alanine aminotransferase (U/L), hemoglobin (gr/dL), mean platelet volume (fL), white blood cells ($\times 10^3/uL$), platelets ($\times 10^3/uL$), neutrophil ($\times 10^3/uL$), and lymphocyte ($\times 10^3/uL$)) were recorded. In addition, clinical data such as the presence of comorbid disease, duration of surgery, and tumor stage were noted.

Evaluation of Postoperative Complications After HP

The complications encountered within the first 30 days after the operation were graded according to the Clavien-Dindo classification.^[16] This classification consists of five grades which could be simply divided into minor (grade <III) and major (grade \geq III) complications. The relationship between postoperative complications and factors such as demographic characteristics, pre-operative biochemical values, comorbid diseases, tumor pathological stage, operation time, and colon segments' CD/LI-VD ratios was evaluated.

Statistical Analysis

SPSS 25.0 (IBM Corporation, Armonk, New York, United

States) program was used to analyze the variables. Normal distribution was evaluated with the Shapiro-Wilk test and variance homogeneity was evaluated with the Levene test. Independent Samples t-test together with Bootstrap results were used when comparing quantitative data of the study and control groups according to age, cecum diameter/LI-VD (mm), ascending colon CD/LI-VD (mm), and transverse colon CD /LI-VD (mm) ratios. Mann-Whitney U test was used together with the Monte Carlo results for the descending CD /LI-VD (mm).

After taking the effects of age and gender into consideration, the partial correlation test was used to examine the correlation between variables. For the comparison of categorical variables, the Pearson Chi-square test was used with the Fisher Exact test results, while the Fisher-Freeman-Halton test was used with the Monte Carlo Simulation technique. The sensitivity and specificity of the relationship between the classification distinguished by the cut-off value calculated from the transverse colon CD/LI-VD (mm), descending colon CD /LI-VD (mm), and the Clavien-Dindo variable, and actual classifications were analyzed with the Receiver

Operating Curve (ROC) analysis. Quantitative variables were shown as mean±SD (standard deviation) and median (minimum/maximum). Categorical variables were noted as n (%). Variables were examined at 95% confidence level and only p-value levels <0.05 were considered significant.

RESULTS

Study Population

Forty-nine patients (37 [75.5%] male, 12 [24.5%] female) with a mean age of 65.59 years (range 28–89 years) were included in the tumor group. In the tumor group, the tumor was located in the sigmoid in 34 patients (69.4%) and in the rectosigmoid in 15 patients (30.6%) (Table 1).

Post-operative Complications

Post-operative complications after HP in the tumor group were graded with Clavien-Dindo classification. Thirty-three patients (67.3%) had Grades I and II complications (minor), while 16 (32.7%) had Grade III and above (major) (Table 1).

Table 1. Distribution of the tumor group according to gender, comorbid diseases, Clavien-Dindo classification, tumor location, and tumor stage

	n	%
Gender		
Female	12	24.50
Male	37	75.50
Tumor location		
Sigmoid	34	69.40
Rectosigmoid	15	30.60
Comorbid diseases		
Diabetes mellitus	9	18.4
Cardiac disease	4	8.2
Chronic renal failure	2	4.1
Chronic obstructive pulmonary disease	2	4.10
Tumor Stage		
I	1	2.00
II	24	49.00
III	20	40.80
IV	4	8.20
Clavien-Dindo Classification		
<III (minor)		
I	24	49.00
II	9	18.40
≥III (major)		
III	4	8.20
IV	6	12.20
V	6	12.20

Five patients (10.2%) with Grade III and above complications were re-operated due to ostomy necrosis and deterioration of general conditions (Table 2). In those patients, intraoperative exploration revealed colon necrosis and segmental resection was performed in four while total colon resection in one patient (Table 2).

Colonic fistula developed in one patients and intra-abdominal bleeding occurred in one patient in the post-operative period. These patients re-operated subsequently (Table 2). Segmental bowel resection and colostomy revision were performed in the patient who developed colon fistula and general condition worsening. Hemostasis was achieved in the patient who developed intra-abdominal bleeding.

Evisceration developed in two patients who were re-operated (Table 2). Both patients were re-operated due to poor general condition, evisceration, and peritonitis in the post-operative period. A drainage system was applied by intra-abdominal irrigation during surgery.

In total, sepsis developed in 12 (24.4%) of the patients with Grade III and above complications, while 6 of 12 patients that developed sepsis recovered with medical and supportive treatment (Two of these patients had been operated on for ostomy necrosis) and 6 (12.2%) of them died (One of the patients was operated on for ostomy necrosis) (Table 2)].

While normal post-operative period was observed in 24 patients (48.9%) with Grades I and II complications, 9 (18.3%) developed complications which required supportive treatment (ileus in 4 [8.1%], wound infection in 3 [6.1%], and ischemia in the ostomy in 2 [4%]) (Table 2).

Evaluation of CD/LI-VD Ratio

In our study, CD/LI-VD ratios decrease toward the cecum, ascending colon, transverse colon, and descending colon in both the control and tumor groups (Table 3).

The CD/LI-VD ratio of colon segments (cecum, ascending, transverse, and descending colon) proximal to the tumor in the tumor group was significantly higher than that of the control group (p<0.001) (Table 3).

Pre-operative transverse and descending colon CD/LI-VD ratios were found to be significantly associated with post-operative complications in the tumor group (p<0.001 and p=0.015, respectively) (Table 4). In the ROC analysis of transverse colon CD/LI-VD ratios, the cut-off value for prediction of major post-operative complications was found to be 1.52. The sensitivity of the cut-off value in predicting Clavien-Dindo classification (≥III and <III) was 81.3% and specificity was 60.6% (p=0.013) (Table 5 and Fig. 2). The cutoff value for the descending colon was 1.21 (sensitivity 87.5% and specificity 54.5%), and was also significant in predicting the

Table 2. Postoperative complications in the tumor group

	Total	Re-operation	ICU	Sepsis	Death	SMM
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Clavien-Dindo ≥III (major)						
Total	16 (32.6)**	9 (56.2)* (18.3)**	16 (100)* (32.6)**	12 (75.0)* (24.4)**	6 (37.5)* (12.2)**	–
Ostomy necrosis	5 (10.2)**	5 (31.2)*	5 (31.2)*	3 (18.7)*	1 (6.2)*	–
Colonic fistula	1 (2)**	1 (6.2)*	1 (6.2)*	–	–	–
Bleeding	1 (2)**	1 (6.2)*	1 (6.2)*	–	–	–
Evisceration	2 (4)**	2 (12.5)*	2 (12.5)*	2 (12.5)*	–	–
Multiple organ failure	7 (14.2)**	–	7 (43.7)*	7 (43.7)*	5 (31.2)*	–
Clavien-Dindo <III (minor)						
Total	33 (67.3)**	–	–	–	–	9 (27.2)*
NPC	24 (48.9)**	–	–	–	–	0
Ostomy ischemia	2 (4)**	–	–	–	–	2 (6)*
Ileus	4 (8.1)**	–	–	–	–	4 (12.1)*
Wound infection	3 (6.1)**	–	–	–	–	3 (9)*

*Calculated for cases with Clavien-Dindo classification (<III) or (≥III). **Percentages were calculated by dividing number of patients with complication by the total number of patients (n=49). ICU: Intensive care unit; NPC: Normal postoperative course; SMM: Supportive medical management.

Table 3. Comparison of the tumor and control groups in terms of gender, age, and colon segments CD/LI-VD ratio

	Tumor group (n=49)	Control group (n=49)	p
Gender, n (%)			
Female	12 (24.5)	14 (28.6)	0.819 ¹
Male	37 (75.5)	35 (71.4)	
Age (years), mean±SD	65.59±13.32	64.84±13.51	0.805 ²
Cecum diameter/LI-VD, mean±SD	2.06±0.47	1.05±0.26	<0.001 ²
Ascending colon CD/LI-VD, mean±SD	1.77±0.39	0.86±0.22	<0.001 ²
Transverse colon CD/LI-VD, mean±SD	1.56±0.31	0.83±0.21	<0.001 ²
Descending colon CD/LI-VD, Median (Min./Max.)	1.30 (0.50/1.95)	0.58 (0.33/0.89)	<0.001 ³

¹Pearson Chi-Square Test (Exact). ²Independent samples t-test (Bootstrap). ³Mann-Whitney U test (Monte Carlo). SD: Standard deviation; Min.: Minimum; Max.: Maximum; CD/LI-VD: Colon diameter/first Lumbar vertebra body diameter.

Clavien-Dindo classification (p=0.042) (Table 5 and Fig. 2).

No correlation was found between the Clavien-Dindo grades and either the cecum or the ascending CD/LI-VD (p=0.225 and p=0.237, respectively) (Table 4).

Evaluation of Biochemical and Other Parameters

Pre-operative Hgb, WBC, PLT, MPV, NLR (neutrophil lymphocyte ratio), AST, ALT, and creatinine values also had no correlation with the Clavien-Dindo classification (p>0.05), (Table 4). The pre-operative transverse colon CD/LI-VD ratio was associated with the blood urea level (Correlation co-

efficient (r): 0.295, p=0.044) (Table 4). A positive correlation was observed between the preoperative blood urea level and postoperative complications (Clavien-Dindo classification) (r=0.348, p=0.015) (Table 4). Urea levels of two patients with chronic kidney disease were excluded from the analysis while investigating the relationship between urea and post-operative complications.

It was observed that age, gender, subcutaneous fat thickness, comorbid diseases, duration of surgery, and tumor stage were not related to postoperative complications (p>0.05 for all) (Table 4).

Table 4. Relationship of CD/LI-VD ratios of preoperative colon segments with preoperative biochemical parameters, tumor stage, subcutaneous thickness, operation time and Clavien-Dindo classification in the tumor group

	*Cecum diameter/LI-VD (mm)		*Ascending colon CD/LI-VD (mm)		Transverse *colon CD/LI-VD (mm)		*Descending colon CD/LI-VD (mm)		**Clavien-Dindo Classification	
	r	p	r	p	r	p	r	p	r	p
Age	-	-	-	-	-	-	-	-	0.254	0.082
SCT (mm)	-0.169	0.257	-0.070	0.642	-0.157	0.291	-0.050	0.741	-0.087	0.555
OT (min)	0.017	0.908	-0.163	0.274	0.023	0.880	0.065	0.662	0.077	0.604
Hgb (gr/dL)	0.228	0.124	0.303	0.038	0.136	0.360	0.283	0.054	-0.005	0.972
MPV (fL)	0.150	0.313	0.206	0.165	0.108	0.470	-0.002	0.991	0.240	0.100
Wbc (10 ³ /uL)	0.032	0.828	0.034	0.820	-0.032	0.833	-0.021	0.889	0.067	0.650
PLT (10 ³ /uL)	0.094	0.531	-0.061	0.684	0.043	0.773	-0.115	0.442	0.051	0.731
Neutrophil (10 ³ /uL)	-0.011	0.941	-0.034	0.823	-0.050	0.739	-0.053	0.722	0.058	0.694
Lymphocyte (10 ³ /uL)	0.132	0.375	0.162	0.275	0.267	0.070	0.149	0.318	-0.120	0.416
NLR	-0.003	0.982	-0.014	0.925	-0.245	0.097	-0.090	0.549	-0.040	0.790
Urea (mg/dL)	0.247	0.094	0.116	0.437	0.295	0.044	0.189	0.203	0.348	0.015
Creatinine (mg/dL)	-0.145	0.330	-0.217	0.143	-0.008	0.958	-0.062	0.681	0.048	0.747
AST (U/L)	0.195	0.189	0.077	0.605	-0.130	0.383	-0.234	0.114	0.019	0.898
ALT (U/L)	0.296	0.043	0.201	0.175	0.055	0.712	-0.047	0.756	0.072	0.626
Tumor Stage	-0.152	0.307	-0.125	0.403	-0.244	0.099	-0.137	0.358	-0.189	0.198
Clavien-Dindo Classification	0.180	0.225	0.176	0.237	0.506	<0.001	0.354	0.015	-	-

Partial Correlation Test; *Gender and Age variables were taken under control together; **Gender variable was taken under control, r: Correlation coefficient. SCT: Subcutaneous fat thickness; CD: Colon diameter; OT: Operation time; Hgb: Hemoglobin; MPV: Mean platelet volume; Wbc: White blood cell; PLT: Platelets; AST: Aspartate amino transferase; ALT: Alanine amino transferase; CD/LI-VD: Colon diameter/first Lumbar vertebra body diameter.

Table 5. The power of the Receiver Operating Curve (ROC) curve in predicting Clavien-Dindo grade based on preoperative transverse and descending colon CD / LI-VD ratios, and preoperative urea in the tumor group

Clavien-Dindo	Cut-Off	Sensitivity	Specificity	AUC (SE)	P
Transverse Colon CD/LI-VD	1.52	81.3%	60.6%	0.720 (0.081)	0.013
Descending Colon CD/LI-VD	1.21	87.5%	54.5%	0.681 (0.081)	0.042
Blood Urea (mg/dL)	38	93.8%	42.4%	0.655 (0.080)	0.080

Roc Curve Analysis (Youdenindex J - Honley&McNell), AUC: Area under the ROC curve. SE: Standard Error; CD/LI-VD: Colon diameter /first Lumbar vertebra body diameter.

No correlation between comorbidity and Clavien-Dindo classification was detected (p=0.705) (Table 6).

DISCUSSION

HP is a generally preferred surgical technique in AOLCRC cases because of short operation time, lack of intestinal anastomosis, and less post-operative complications.^[9,10] However, a review of the literature showed that the rate of postoperative complications related to HP is still quite high.^[11,12] Concordantly, we observed that major post-operative complication rate was high in our cohort. In addition, these complications were found to correlate with high pre-operative transverse and descending colon CD/LI-VD ratios.

In our study, post-operative major complications developed in 32.6% of patients. Among those complications, sepsis developed in 24.4%, ostomy and colon necrosis in 10.2% of patients, re-operation was required in 18.3%, and mortality rate in our cohort was 12.2%. There are very few studies in the literature that evaluated the post-operative complications of HP. In one of the largest series with 226 patients, Kube et al.^[17] reported that 27% of patients developed surgical method-specific post-operative complications. Re-laparotomy was reported in 8.8% of these patients and mortality rate was 7.1%. In two different studies with 29 and 41 patients, pelvic abscess was reported in 17.2% and 12.2%, respectively, with the re-laparotomy rate of 15% in the latter.^[18,19] Similarly, in the study of 163 patients by Tøttrup et al.,^[20] pelvic sepsis

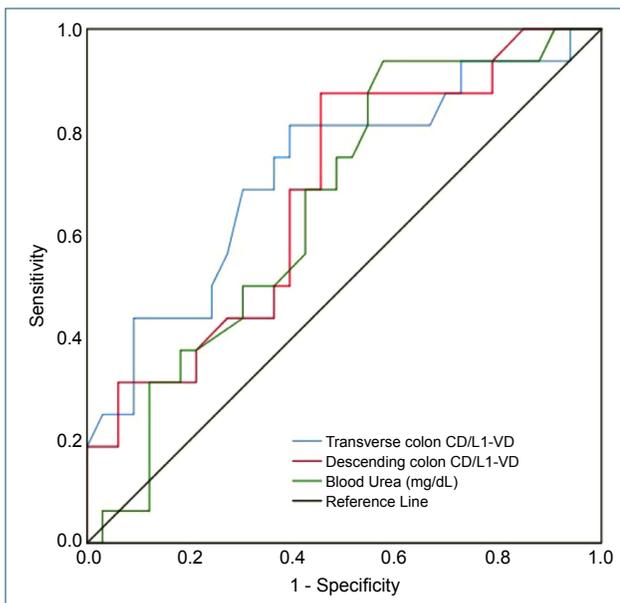


Figure 2. Receiver Operating Curve curve for predicting Clavien-Dindo grade based on pre-operative urea levels, transverse and descending colon diameter (CD)/first Lumbar vertebra body diameter (L1-VD) ratios in the tumor group.

was seen in 18.6% of patients. According to those results, it is obvious that the rates of re-laparotomy and sepsis in HP are significantly high. This could be explained by bacterial translocation from bowel to intraperitoneal cavity and micro perforation due to excessive distension of the colon in the preoperative period which could lead to the development of sepsis. In our opinion, dilated colon segments that are not resected in HP are a potential source of aggravation of sepsis due to wall damage which may increase mortality subsequently.

Table 6. Relationship of comorbid diseases with Clavien-Dindo classification in the tumor group

	Comorbidity (No)	Comorbidity (Yes)	p
	(n=39)	(n=10)	
	n (%)	n (%)	
Clavien-Dindo Classification			
I	20 (51.3)	4 (40.0)	0.705 ¹
II	8 (20.5)	1 (10.0)	
III	3 (7.7)	1 (10.0)	
IV	4 (10.3)	2 (20.0)	
V	4 (10.3)	2 (20.0)	
Clavien-Dindo Classification			
<III (minor)	28 (71.8)	5 (50.0)	0.261 ²
≥III (major)	11 (28.2)	5 (50.0)	

¹Fisher Freeman Halton Test (Monte Carlo). ²Fisher Exact test (Exact).

The pathophysiology of this process is not very complex. In complete obstruction of the colon due to a tumor, the pressure in the colon lumen increases as a result of the increase in the amount of gas, liquid, and stool. This increased pressure can cause disruption of circulation in the colon wall as well as muscle rupture. As a result, necrosis and micro perforation can develop in the colon wall and cause sepsis.^[4,5,21] In HP, after the colon segment containing the tumor is resected according to oncological principles, the distal end of the remaining proximal dilated colon is mouthed to the skin and a colostomy is created. The proximal end of the colon distal to the tumor is covered.^[22] In our opinion, failure to recognize ischemic areas and micro perforations progressing to necrosis on the wall of the unresected colon segments seems to play an important role in the development of postoperative complications.

In relation to this pathophysiological basis, we tried to investigate the role of a new prognostic marker (CD/L1-VD ratio) in this study to predict major complications after HP. We chose this ratio to create an individually based marker which would not depend on age or gender. A pool of age- and gender-matched control group was also identified to compare this ratio on both control subjects with normal bowel diameters and patients with AOLCRC. According to our experience, the unresected dilated colon segments in HP may have deteriorated wall structure due to distension in the preoperative period and we believe that this change constitutes the potential for post-operative complications. In our study, we found that transverse and descending colon CD /L1-VD ratios (≥ 1.52 and 1.21 , respectively) were promising prognostic parameters for post-operative major complications with high sensitivity and reasonable specificity. To the best of our knowledge, there has not been any reported study using this marker as a prognostic parameter in patients with acute obstructive colon tumors; therefore, we could not make a comparison. Nevertheless, the study of Chao et al.^[13] demonstrates the potential usage of this parameter in pediatric patients with toxic megacolon which subsequently inspired us to investigate its role in adults. In that study, CD/L1-VD ratio was studied as a new parameter in a group of pediatric patients with non-typhi Salmonella to predict the possibility of intestinal perforation.^[13] They reported that if the ratio CD/L1-VD increase above 2.5 in pediatric toxic megacolon, the perforation rate increases, and the clinical status of the patient worsens.^[13] This study shows that the colon CD/L1-VD ratio has predictive value for perforation. In our study, it was determined that this rate has an important predictive value for post-operative major complications.

Evaluation of major post-operative complications in our study suggested that bleeding might have developed due to insufficient hemostasis. Sepsis (56%) and conditions accompanied by deterioration of general condition and requiring reoperation such as ostomy necrosis (31.2%), colonic fistula (6.2%), and evisceration (12.5%) were among other major complications. The correlation of these complications with

high pre-operative transverse and descending CD/LI-VD ratios supports our hypothesis.

According to Laplace's Law, in flexible tubes (e.g., long balloon) with sections of different diameters, the most expansion with the least pressure occurs in the section with a larger diameter.^[23,24] As the pressure increases, the expansion progresses from a large diameter area to a smaller diameter area, because the wall resistance in the section with the large diameter is higher than the wall resistance in the section with the small diameter.^[24] According to this law, in left colon obstructions, since the cecum has the largest diameter, the most lumen pressure and wall damage occur in this area.^[25] Moreover, as the pressure in the cecum increases, dilatation occurs in other segments. In other words, the dilatation rate in the segments with narrow diameter is proportional to the pressure increase in the cecum. In our study, it is seen that the CD/LI-VD ratio of cecum, ascending colon, transverse and descending colon were from greater to smaller. According to our results, the significance of the transverse and descending colon CD / LI-VD ratio in demonstrating colon wall damage is clarified by Laplace's Law.

Tumor resection and colonic resection are the preferred methods in left-sided colorectal cancers based on oncological principles.^[10] In addition, bridging to elective surgery with a self-expandable stent is also recommended as well as emergency surgery in the emergency treatment of AOLCRC according to the latest guidelines. Although high clinical success has been reported with these self-expandable stents, complications are not uncommon, the most common of which is the colon perforation due to stent or air insufflation.^[6,26-28] Our study is important in terms of showing that the possibility of ischemia and necrosis in the dilated colon wall increases after the transverse and descending colon CD/LI-VD exceeds the cut-off value. Therefore, in the candidates either for colon resection or stent application, the risk of perforation of the colon wall should be considered in patients where the transverse and descending colon CD/LI-VD cut-off value is exceeded. In our opinion, in AOLCRCs, total resection of the dilated colon may be recommended if the transverse and descending CD ratio is above the cut-off value to avoid more serious post-operative complications. If this ratio is below the cut-off value, the possibility of necrosis and micro perforation in the colon may be low and therefore partial colon resection may be preferred instead of total colectomy. However, our results warrant validation with randomized prospective studies before incorporating this marker into routine clinical practice.

The release of vasoactive amines from the intestinal mucosa increases due to intestinal distension. This causes fluid loss to the intestinal lumen and 3rd cavities. In turn, this intravascular fluid loss may lead to impairment of kidney functions.^[21] This physiopathology explains the correlation of blood urea level with the diameter of the transverse colon during the pre-operative period in our study. Hsu et al.^[29] found that fluid

and electrolyte imbalance in such patients posed a risk for postoperative complications. Similarly, in our study, we observed that major postoperative complication rate increased in patients with pre-operative acute renal failure.

Risk factors such as comorbid diseases (chronic renal failure, cardiac failure, diabetes mellitus, malnutrition, and immunosuppression), advanced age, and high American Society of Anesthesiologists score have been held responsible for postoperative complications in HP.^[1,30,31] In our study, comorbid diseases were not identified as risk factors for post-operative complications. This result was thought to be due to the insufficient number of cases with comorbid diseases. In addition, there was no correlation between preoperative infectious parameters and post-operative complications. This may have resulted from the exclusion of patients with sepsis and intra-abdominal perforation.

Our study has few limitations. First, it was a single-center retrospective study. Secondly, our study population was relatively small; however, this was a hypothesis generating study and we hope that our idea could be inspiring for larger scale future research. Finally, we did not have a separate cohort (e.g., patients with colon obstruction due to various reasons other than tumor) for comparison. Nevertheless, we had a control group without any bowel pathology to compare the imaging data (i.e., CD/LI-VD and subcutaneous fat thickness).

Conclusion

There is still no consensus regarding the treatment options for emergency AOLCRC. In our study, we found that postoperative major complications increased in patients with transverse and descending colon CD/LI-VD ratio higher than the proposed cut-off value. In those cases, choosing the surgical method considering this cut-off value may reduce postoperative complications. Our study is the first research on this subject and further prospective and comparative studies are warranted for validation of our preliminary results.

Highlights

In patients undergoing Hartmann's procedure due to acute obstructive left-sided colorectal cancers

- As the colon diameter proximal to the tumor increases, the rate of post-operative major complications increases.
- The ratios of the pre-operative transverse and descending colon diameters (CD to the first lumbar vertebra corpus diameter (LI-VD) ≥ 1.52 and 1.21 (cutoff), respectively, are promising prognostic parameters for prediction of post-operative major complications.
- There is a positive correlation between transverse colon CD/LI-VD ratio and pre-operative blood urea levels.

Ethics Committee Approval: This study was approved by the İzmir Tepecik Training and Research Hospital Clinical Research Ethics Committee (Date: 13.07.2017, Decision No: 26).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: A.K.K., B.Ç., H.Ş., K.T., K.K.B., Ö.Z., G.A.; Design: A.K.K., B.Ç., H.Ş., K.T., K.K.B., Ö.Z., G.A.; Supervision: A.K.K., B.Ç., H.Ş., K.T., K.K.B., Ö.Z., G.A.; Data: A.K.K., B.Ç., H.Ş.; Analysis: A.K.K., B.Ç., H.Ş.; Literature search: A.K.K., H.Ş., B.Ç.; Writing: A.K.K., H.Ş., B.Ç.; Critical revision: A.K.K., B.Ç., H.Ş.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

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ORJİNAL ÇALIŞMA - ÖZ

Akut obstrüktif sol kolon tümörü nedeniyle Hartman prosedürü uygulanan hastalarda yeni bir prognostik belirteç

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AMAÇ: Akut obstrüktif sol kolorektal kanserlerde (AOSKRK), tümörün proksimalindeki kolon segmentlerinin distansiyonu sonucu kolon duvarında hasar meydana gelebilir. Amacımız Hartmann prosedürü (HP) uygulanan hastalarda, ameliyat öncesi abdominal bilgisayarlı tomografi (BT) taramasında dilate kolon çapının lomber vertebra korpus çapına oranı ile ameliyat sonrası komplikasyonlar arasındaki ilişkiyi değerlendirmektir.

GEREÇ VE YÖNTEM: Tümör grubu, acil şartlarda AOSKRK nedeniyle HP uygulanan 49 hastadan oluşturuldu. Kontrol grubu, gastrointestinal sistem dışındaki patolojiler nedeniyle abdominal BT'si olan, batın ameliyatı öyküsü olmayan, tümör grubu ile yaş ve cinsiyet bakımından uyumlu 49 kişiden oluşturuldu. Her iki grupta, her hastanın aksiyel BT görüntülerinde kolon çapının (KÇ) ilk lomber vertebra korpusunun çapına (L1-VÇ) oranı ölçüldü. Ameliyat sonrası komplikasyonlar (Clavien-Dindo sınıflaması -major (grade \geq III), minor (grade <III)) ile demografik özellikler, ameliyat öncesi biyokimyasal değerler, komorbid hastalıklar, tümör patolojik evresi, operasyon süresi ve kolon segmentlerinin KÇ/L1-VÇ oranları arasındaki ilişki değerlendirildi.

BULGULAR: Tümör grubunda KÇ/L1-VÇ oranı, kontrol grubuna göre anlamlı derecede yüksekti ($p<0.001$). Tümör grubunda ameliyat öncesi transvers ve inen kolon KÇ/L1-VÇ oranında artış, majör ameliyat sonrası komplikasyonlar için prognostik parametre olarak bulundu (sırasıyla $p<0.001$, $p=0.015$). KÇ/L1-VÇ oranlarının cut-off değerleri sırasıyla 1.52 ve 1.21 ($p=0.013$, $p=0.042$) tespit edildi. Ameliyat öncesi transvers kolon KÇ/L1-VÇ oranındaki artış da kan üre düzeyindeki artışla ilişkili bulundu ($p=0.044$). Ameliyat öncesi kan üre düzeyleri ile ameliyat sonrası komplikasyonlar arasında pozitif korelasyon gözlemlendi ($p=0.015$).

TARTIŞMA: AOSKRK'de ameliyat öncesi transvers ve inen kolon KÇ/L1-VÇ oranları, majör ameliyat sonrası komplikasyonlar için umut verici prognostik parametrelerdir.

Anahtar sözcükler: Akut kanı; Hartmann prosedürü; ileus; kolon tümörü; Laplas kanunu; obstrüktif sol kolorektal tümör.

Ulus Travma Acil Cerrahi Derg 2022;28(9):1248-1257 doi: 10.14744/tjtes.2021.67792