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Persistent Descending Mesocolon as a Risk Factor of Laparoscopic Surgery for Colorectal Cancer: A Single Institution Experience

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The objectives of this study are to clarify the significance of persistent descending mesocolon (PDM), a kind of intestinal malrotation, in laparoscopic colorectal surgery and present potentially useful preoperative diagnostic methods for PDM. Although several risk factors for laparoscopic colorectal surgery have been convincingly reported, the impact of PDM on laparoscopic surgery for colorectal cancer remains less studied. This was an observational study with a retrospective analysis. A consecutive 110 patients undergoing laparoscopic colorectal surgery for colorectal cancer were included. To identify risk factors for operative time of laparoscopic surgery for colorectal cancer, we examined age, sex, body mass index, American Society of Anesthesiologists Performance Status score, tumor location, depth of tumor invasion, lymph node metastasis, and PDM as potential risk factors. For identification of appropriate preoperative diagnostic imaging, we reviewed three-dimensional vessel images reconstructed from computed tomographic slice data of all patients. During the study period, no effective pre- or intraoperative diagnoses of PDM were achieved. A total of 4 patients were diagnosed with PDM. Sex ($P = 0.0032$); tumor location ($P = 0.0044$); lymph node metastasis ($P = 0.022$); and PDM ($P = 0.0007$) were identified as risk factors based on multivariate analysis. A ventrally branched left colic artery visualized by three-dimensional imaging appeared to be a highly specific feature of PDM. Laparoscopic surgery for colorectal cancer with PDM was difficult without the recognition of PDM. PDM was well-defined

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preoperatively using three-dimensional vessels images reconstructed from computed tomographic slice data.

Key Words: Persistent descending mesocolon – Laparoscopic surgery – Colorectal cancer

The benefits and safety of laparoscopic surgery for colorectal cancer (CRC) in comparison with conventional open surgery have been well clarified: positive effects including decreased pain, reduced postoperative paralytic ileus, improved postoperative pulmonary function, and reduced postoperative wound infection, result in shorter hospitalization.[1–6] The oncologic long-term outcome after laparoscopic surgery for colon cancer is comparable with that after conventional open surgery.[7–10] Moreover, due to its magnification effect on visualization, laparoscopic surgery is suitable for complete mesocolic excision, central vascular ligation, and Japanese D3 lymph node dissection, thereby improving the prognosis of the patients.[11–14] On the other hand, some reports indicate that risk factors of laparoscopic colorectal surgery include age; obesity; American Society of Anesthesiologists Performance Status (ASA-PS) score; and/or previous radiation therapy.[15–17]

Persistent descending mesocolon (PDM) stems from failure of the primitive dorsal mesocolon to fuse with the parietal peritoneum.[18] The colon might be located midline or even displaced toward the right abdomen where it might become fixed in a position adjacent to the cecum.[18] This abnormality was first reported in the gynecologic field,[19] followed by a report in the radiologic field.[20] During normal embryonic development, following the return of the distal midgut (postarterial segment) to the peritoneal cavity during the 10th week of gestation and subsequent completion of the rotational process, the colon assumes an almost normal configuration.[21] On the left side, the hindgut is normally displaced laterally from the midline position by the jejunal loops with the delineation of the future descending colon and splenic flexure. PDM is believed to develop due to abnormalities in this process.[21]

The impact of congenital positional anomaly of the colon and rectum on laparoscopic colorectal surgery remains more or less unknown. The purpose of the present study was primarily to characterize the features of laparoscopic surgery for CRC patients with PDM and also to identify an effective preoperative diagnostic procedure for PDM.

Materials and Methods

Patients

Medical records, radiologic images, and recorded operative procedures of patients undergoing laparoscopic colorectal surgery for CRC at the Department of Surgery, Itami City Hospital, between January 2013 and June 2014 were used in this retrospective study. This retrospective study was approved by Review Board at Itami City Hospital.

Preoperative diagnostic modalities

Standard blood analyses including serum carcinoembryonic antigen (CEA) levels were performed. Colonoscopy using a standard flexible endoscope was performed to obtain information on tumor location and for obtaining biopsy specimens. The diagnosis of CRC was confirmed by histologic examination of tissue biopsies.

Computed tomography (CT) images were obtained with a scanner composed of 64 detectors (LightSpeed VCT, GE Healthcare Japan, Tokyo, Japan). The scanning area of the contrast-enhanced CT was set to include the area from the neck to the femur, according to the scout image. For enhanced CT examination, a nonionic construct agent in 300 mg of iodine/mL (Omnipaque 300, Daiichi Pharmaceutical, Tokyo, Japan) was infused at 5 mL/second using a standard automatic injector in a total volume of 150 mL. Arterial phase images were obtained by scanning from around 20 seconds after the start of the injection. The scanned area included the area extending from the dome of the liver to the pelvic floor. Venous images were obtained by scanning from 50 or 85 seconds after the start of the injection. The scanned area included the area extending from the neck to the pelvic floor. For reconstruction of three-dimensional (3D) vessel images, slice data obtained from these double phases were transferred to a workstation (AW VolumeShare 2, GE healthcare), where individual data at each phase were converted to 3D recon-

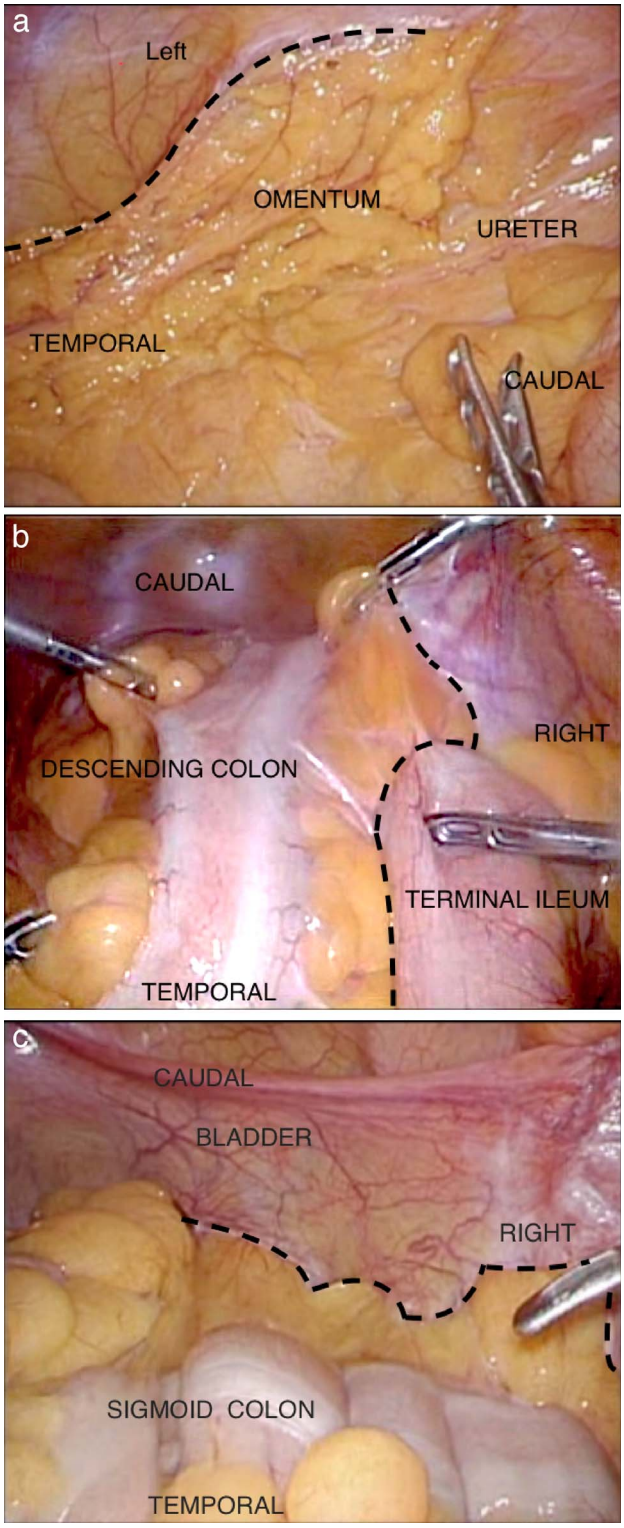

Fig. 1 Laparoscopic findings in PDM cases. (a) Omentum adhering to the left Monk's white line, to which the descending colon would adhere under normal circumstances. The dashed line indicates the adhesion line of the omentum to the Monk's white line. (b) The descending colon tightly adhered to the mesoileum. The dashed line indicates the adhesion line of the descending colon to the mesoileum and the right side of the pelvic wall. (c) The sigmoid colon was shifted to the median, adhering to the right side of the pelvic wall and the rectovesical pouch. The dashed line indicates the adhesion of the sigmoid colon.

struction images according to the volume rendering technique. The arterial, venous, and tumor images were merged.

Surgical procedures

Two surgeons, who had experienced more than 30 laparoscopic and 30 open operations for CRC, performed the laparoscopic surgery. After placement of 5 ports and exploration of the abdominal cavity under pneumoperitoneum (10 mmHg), resection of the colon or rectum with D2 and/or D3 dissection was performed according to the Japanese Classification of Colorectal Carcinoma (8th edition).[22] The extent of lymph node dissection was defined preoperatively according to the predicted depth of tumor invasion or lymph node metastases obtained by CT images.

For right-sided lesions, the vascular pedicles were divided just peripheral to their origin (D2) or divided at their origin together with removal of the draining lymph nodes (D3). For left-sided lesions, removal of lymph nodes at the root of the superior rectal artery (D2) or at the root of the inferior mesenteric artery was performed with high ligation, or with preservation of the left colic artery (LCA) and ligation of the root of the superior rectal artery (D3). Colonic mobilization was processed from medial to lateral. Resection of the target lesion and reconstruction of the colon and/or rectum were performed via a laparotomy smaller than 5 cm.

Diagnosis of PDM

Final diagnoses of PDM were made postoperatively and based on comprehensive intraoperative findings, which were recorded as movies. In this study, we defined PDM as follows: the omentum adhering to the left-side of the Monk's white line, to which the descending colon usually adheres in normal cases (Fig. 1a); a medially shifted descending colon; a descending colon tightly adhering to the mesoileum (Fig. 1b); and a sigmoid colon tightly adhering to the right side of the pelvic wall and rectovesical pouch (Fig. 1c).

Table 1 Patient characteristics

	Control group (N = 106)	PDM group (N = 4)	*P* value
Age	69.8 ± 0.90	70.3 ± 4.64	0.92
Sex, male/female	50/56	4/0	0.016[a]
BMI, <25/≥25	87/19	3/1	0.73
ASA-PS, 2 or less/3	83/23	3/1	0.877
Tumor location, colon/rectum	61/45	1/3	0.194
Depth of tumor invasion, T2 or less/T3 or more[b]	29/77	0/4	0.113
Lymph node metastasis, negative/positive	50/56	2/2	0.911
Serum CEA levels, ng/mL	12.9 ± 3.3	6.38 ± 17.1	0.71

[a]Value represents χ^2 test.

[b]Japanese Classification of Colorectal Carcinoma, 8th edition.[22]

Statistical analysis

Continuous data are presented as means ± standard deviations. Differences in qualitative variables were assessed using the χ^2 test or Fisher's exact test. Univariate and multivariate stepwise regression analyses were used to identify risk factors for operation time. Variables with P values ≤ 0.05 in univariate analysis were included in the multivariate analysis. Statistical significance was set at $P < 0.05$. All statistical analyses were performed using commercial software (JMP9 for Macintosh, SAS Institute Japan, Tokyo, Japan).

Results

Patients with PDM at a Japanese secondary care institute

Among 110 patients with primary CRC undergoing laparoscopic colorectal surgery, 4 [3.64%; 95% confidence interval (CI), 1.42%–8.98%] were diagnosed with PDM.

Characteristics of patients with CRC and PDM

Table 1 summarizes the clinical data from the 4 CRC patients with PDM. Age; body mass index (BMI); ASA-PS; tumor location; depth of tumor invasion; lymph node metastases; and serum CEA levels of the PDM cases (PDM group) did not differ significantly from those of CRC cases without PDM (control group). Meanwhile, sex differed significantly between 2 groups (control group versus PDM group: 50/56 versus 4/0, $P = 0.016$). No symptoms specific to PDM were observed, including digestive symptoms such as constipation, diarrhea, and body weight.

Factors affecting operative time

Operative time and blood loss of each group (control group/PDM group) were 339.5 ± 10.4 versus 566.3 ± 53.6 minutes ($P < 0.0001$) and 18.7 ± 12.4 versus 242.5 ± 64.1 mL ($P = 0.0604$), respectively. We conducted univariate and multivariate analysis of factors affecting operative time. Age (<75 versus ≥75 years); BMI (<25 versus ≥25); and ASA-PS (0, 1, 2/3) did not appear to influence operative time. According to the univariate analysis, sex (male versus female, $F = 15.7$, $P = 0.0001$); tumor location (colon versus rectum, $F = 13.8$, $P = 0.0003$); depth of tumor invasion [T1, T2/T3, T4 (the Japanese Classification of Colorectal Carcinoma, 8th edition[22]), $F = 4.1$, $P = 0.045$]; lymph node metastasis (negative versus positive, $F = 4.22$, $P = 0.042$); and PDM (control versus PDM group, $F = 17.2$, $P < 0.0001$) were factors significantly affecting operative time. According to the multivariate analysis, sex ($F = 9.1$, $P = 0.0032$); tumor location ($F = 8.48$, $P = 0.0044$); lymph node metastasis ($F = 5.45$, $P = 0.022$); and PDM ($F = 12.3$, $P = 0.0007$) were factors significantly influencing operative time (Table 2).

Table 2 Factors affecting operative time

		Univariate analysis		Multivariate analysis	
	Operative time, min	*F* value	*P* value	*F* value	*P* value
Age, <75/≥75	342.9 ± 13.6/357.1 ± 18.7	0.378	0.54		
Sex, male/female	389.2 ± 14.7/307.8 ± 14.4	15.7	0.0001[a]	9.1	0.0032[a]
BMI, <25/≥25	339.9 ± 12.0/383.3 ± 25.5	2.36	0.13		
ASA-PS, 2 or less/3	335.0 ± 12.3/386.8 ± 24.2	3.65	0.0586		
Tumor location, colon/rectum	313.9 ± 13.8/391.5 ± 15.7	13.8	0.0003[a]	8.48	0.0044[a]
Depth of tumor invasion, T2 or less/T3 or more	311.2 ± 21.0/360.8 ± 12.6	4.1	0.0454	0.0274	0.8689
Lymph node metastasis, negative/positive	324.3 ± 15.7/368.8 ± 14.9	4.22	0.0423[a]	5.45	0.0215[a]
Control group/PDM group	339.5 ± 10.4/566.3 ± 53.6	17.2	<0.0001[a]	12.3	0.0007[a]

[a]Stepwise regression analysis.

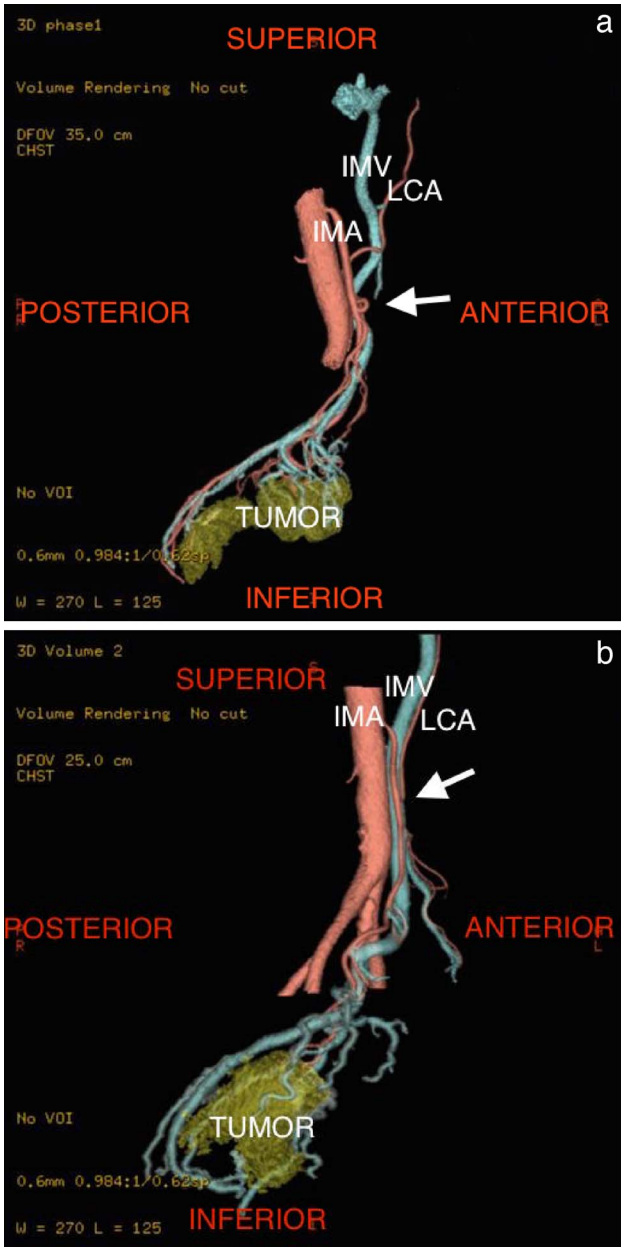

Fig. 2 Representative 3D reconstructed images of the inferior mesenteric vessels of a patient with PDM (a) and normal cases (b).The arrow indicates the root of the LCA. IMV, inferior mesenteric vein.

Specific 3D vessel images of PDM

Retrospectively, we hypothesized that the ventrally branched left colic artery observed on the 3D image reconstructed from CT images (Fig. 2a)—which would be caused by a folded descending mesocolon—might be a specific diagnostic feature of PDM. As expected, in the control group, the left colic artery was seen to branch medially toward the lateral direction (Fig. 2b), except in 1 case with kyphosis. Using this feature as a diagnostic feature of PDM cases, sensitivity was 1.00 (4/4) and specificity was 0.9906 (105/106); the positive and negative predictive value was 0.80 (4/5) and 1.0 (105/105), respectively ([Kappa coefficient], $K = 0.8842$, $P < 0.0001$, Fisher's exact test, Table 3).

Table 3 Co-relationship between PDM and ventrally branched LCA

	Final diagnosis	
Ventrally branched LCA	PDM	Normal
Yes	4	1
No	0	105

Discussion

Recently, laparoscopic surgery for CRC has been widely accepted. The significance of stylized techniques is thought to be critical; however, in some cases, these stylized techniques cannot be adopted due to obesity, severe adhesion, and/or previous radiation therapy.[15–17] On the other hand, the impact of congenital anatomic anomalies on laparoscopic surgery for CRC has not been reported. Since the previously reported frequency of PDM was around 2.4%[23] and the frequency of PDM in this study was 3.64% (4/100; 95% CI, 1.42%–8.98%), surgeons at high-volume centers would frequently encounter cases with PDM and should be aware of this anomaly and its implications.

From our data on operative time, laparoscopic surgery for CRC with PDM tends to be more complicated than that of normal cases, without knowledge of PDM. Retrospectively, the assumed reasons for the difficulty of procedures for CRC with PDM may be considered as follows: First, since the descending colon dislocated into the midline, the descending colon would be misidentified as the sigmoid colon. Second, since the sigmoid colon dislocated into the pelvic space and adhered onto the right side of the pelvis, the sigmoid colon would be misidentified as the rectosigmoid colon. These are the reasons for the misconception that the sigmoid mesocolon is relatively narrow, the sigmoid colon is relatively short, and the space in the undermobilized sigmoid colon is relatively tight. These misunderstandings presumably made the operative procedures difficult and that is why we struggled to operate cases with PDM using a stylized approach.

Over the study period, we were not aware of PDM. Retrospectively, however, the ventrally branched left colic artery (Fig. 2a), clearly delineated by 3D reconstructions of CT images, was diagnostic for PDM patients. By using this feature, accurate preoperative diagnosis could be achieved. In fact, after the study period, we could effectively detect PDM among CRC patients and could develop appropriate preoperative strategies (data not shown). For standardizing operative strategies for CRC cases with PDM, we recommend that first the adhered mesoileum should be flaked from the descending colon; next, to make the colon straight, the adhesion between the sigmoid colon and right side of the pelvic wall and rectovesical pouch should be broken up. After these procedures, the descending and sigmoid mesocolon would be widely expanded and subsequent intrusion into the appropriate layer under the inferior mesenteric artery (IMA), followed by high ligation of IMA, would be processed easily. As for the reconstruction in patients of CRC with PDM, since the descending mesocolon and sigmoid mesocolon were tightly folded and adhere to the small intestine or mesointestine, peeling the sigmoid colon from other tissues without causing injury is challenging. If the intact residual oral colon is too short for reconstruction, it is obvious that a two-stage operation (resection of the target lesion with diverting colostomy and reconstruction) should be considered. For a right-sided colectomy with PDM, mobilization of the cecum—which is thought to be critical for a right-sided colectomy—is difficult due to the limited mobility of the terminal ileum, since the terminal mesoileum is tightly adhered to the sigmoid colon. To mobilize the cecum, careful peeling of this adhesion is required. It would require a long operation time and with no breakthrough knack existing, plodding mobilization is required.

We conclude that surgeons practicing laparoscopic surgery for CRC should be aware of PDM and the operative strategy should be tailored based on the preoperative diagnosis of PDM. Accurate preoperative diagnosis of PDM would allow surgeons to make accurate informed decisions and consents for patients, including long operation time, diverting colostomy, and/or two-stage operations. Because of the nature of the disease and the rarity of PDM, randomized controlled clinical trials are not feasible. Therefore, it is difficult to make definitive treatment recommendations and predict outcomes, especially based on studies of a limited number of patients. Accumulation of more data on PDM is warranted in order to define standard treatment and follow-up protocols.

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