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ORIGINAL ARTICLE

Displacement of the transverse colon is a highly specific computed tomography finding for the preoperative diagnosis of a transomental hernia

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Abstract

Purpose A transomental hernia (TOH) is a rare type of internal hernia and is associated with a high strangulation rate and high mortality rate. Displacement of the transverse colon on computed tomography (CT) may be specific to a TOH and may facilitate an early diagnosis. The aim of this study was to verify the effectiveness of a novel approach assessing displacement of the transverse colon for the preoperative diagnosis of a TOH.

Materials and methods We retrospectively reviewed the CT and operative data of 113 patients who underwent surgery for small bowel obstruction (SBO) between 2011 and 2018. The proportion of transverse colon loops posterior to dilated intestinal loops (PTPI) was calculated.

Results The patients were divided into a TOH group ($n=7$) and other SBO group ($n=106$). The median PTPI was significantly higher in the TOH group than in the other SBO group (67% [0–97%] vs. 0% [0–100%], Wilcoxon's test, $p=0.03$). A receiver operating characteristic curve showed that when the PTPI was ≥ 57%, its sensitivity and specificity for a TOH were 71% and 94%, respectively.

Conclusion The PTPI is a reliable quantitative measure to distinguish a TOH from other types of SBOs.

Keywords Transomental hernia · Internal hernia · Transverse colon · Computed tomography

Abbreviations

CT	Computed tomography
PTPI	Proportion of transverse colon loops posterior to dilated intestinal loops
ROC	Receiver operating characteristic
SBO	Small bowel obstruction
TOH	Transomental hernia

Introduction

An internal hernia is an acute or chronic protrusion of the small bowel through a mesenteric or peritoneal hernial orifice. It is one of the causes of small bowel obstruction (SBO), and its incidence in cases of SBO has been reported to be 0.6–5.8% [1]. A transomental hernia (TOH) is a rare type of internal hernia, accounting for approximately 4% of all internal hernias [2]. The pathogenesis of a TOH involves congenital factors, spontaneous development, senile atrophy, trauma, surgery, or inflammation [3, 4]. Yamaguchi classified TOHs as follows: type A (peritoneal cavity → peritoneal cavity), type B (peritoneal cavity → omental bursa → peritoneal cavity), and type C (peritoneal cavity → omental bursa). Type A is the most common TOH type [5].

Surgical treatment involves the reduction of the herniated intestinal segment. If necrosis, perforation, or irreversible ischemia of the herniated viscera is noted, organ resection is necessary [2]. To prevent subsequent herniation, the omental defect should be resolved with surgical interventions, including division, suturing, and omentectomy [6].

Despite the high mortality rate associated with a TOH [7], the definitive diagnosis is usually established intraoperatively [8, 9]. To our knowledge, no study on the preoperative diagnosis of a TOH has been reported, and its preoperative diagnosis remains a challenge.

According to some studies, displacement of the transverse colon may be a specific CT finding of a TOH [10–12], and it

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involves the presence of dilated small bowel loops anterior to the transverse mesocolon, which is rare in other types of SBO cases. This is based on the hypothesis that, in TOH cases, small bowel loops that are naturally located posterior to the transverse mesocolon pass through the omental hiatus and protrude anterior to the transverse colon [11].

The objective assessment of these atypical loops anterior to the transverse mesocolon with a quantitative method might provide a reliable approach to correctly diagnose TOH preoperatively. We developed a novel approach to quantitatively assess the displacement of the transverse colon posterior to obstructed intestinal loops. The aim of this study was to verify the effectiveness of our novel approach for the preoperative diagnosis of a TOH in patients diagnosed with SBO.

Materials and methods

Patients

Our institutional review board approved this retrospective study, and each patient provided informed consent. The study included a consecutive series of 132 patients who underwent surgery in our hospital and had a surgical diagnosis of SBO between 2011 and 2018.

Assessment of CT findings and division into groups

First, we retrospectively reviewed the preoperative CT images of the 132 study patients before inspecting the detailed clinical records. They included 94 contrast-enhanced CT images and 38 non-contrast CT images. The slice thickness of all CT images was 5 mm. Images were blindly reviewed by a single gastroenterological surgeon (Author R.I.) on a Picture Archiving and Communication System. To quantify the dilated loops of the obstructed intestine located anterior to the transverse colon, we considered the proportion of transverse colon loops posterior-to-dilated intestinal loops (PTPI). This proportion was calculated using the number of transverse colon loops posterior to dilated loops of the obstructed intestine on axial CT as the numerator and the number of transverse colon loops on whole axial CT as the denominator. A representative case is presented in Fig. 1. In the image slice of Fig. 1a, one transverse colon loop was identified, and this loop was posterior to dilated intestinal loops. In the image slice of Fig. 1b, three transverse colon loops were identified, and one of these three transverse colon loops was posterior to dilated intestinal loops. Similar to this case, we counted the number of whole transverse colon loops and the number of transverse colon loops posterior to dilated intestinal loops. A dilated intestinal loop was defined as an intestinal loop with diameter larger than 2.5 cm [13]. Nineteen patients in whom the transverse colon was not clearly identified in CT images were excluded (Fig. 2) and 14 cases with non-contrast CT images were included in these 19 patients.

Second, we reviewed the operative information of the 113 patients eligible for further analyses and divided the patients into the following two groups: TOH group ($n=7$) and other-type SBO group (other SBO group, $n=106$). The former group and the latter contained 1 (in 7) and 23 (in 106) cases with non-contrast CT images, respectively.

End points

The primary endpoint of this study was the sensitivity and specificity of the PTPI for the preoperative diagnosis of a TOH. The secondary endpoints were the disease duration, number of patients undergoing intestinal resection, and number of hospital deaths in the two groups.

Statistical analysis

Wilcoxon's test and Fisher's exact test were used to verify the numerical and proportional differences, respectively, between the two groups. We used receiver operating characteristic (ROC) curve analysis to verify the capability of the PTPI for the diagnosis of a TOH. All statistical analyses were performed using SPSS ver. 21 software (IBM Corp., Armonk, NY, USA). A p value <0.05 was considered statistically significant.

Results

Patient characteristics

The characteristics of the patients in the TOH and other SBO groups are summarized in Table 1. There were no significant differences in sex, age, or body mass index between the groups. However, the proportion of patients with an abdominal surgery history was significantly different between the TOH and other SBO groups (85% [$n=6$] and 26% [$n=28$], respectively). Of the seven patients in the TOH group, six had type A TOH and one had type C TOH, according to Yamaguchi classification [5]. Of the 106 patients in the other SBO group, 7 had internal hernias, 12 had external hernias, 66 had adhesive SBOs, 5 had peritoneal carcinomatosis, 11 had small bowel volvulus, 1 had small intestine carcinoma, 1 had Ladd ligament, 1 had intussusception, 1 had bezoar, and 1 had foreign bodies.

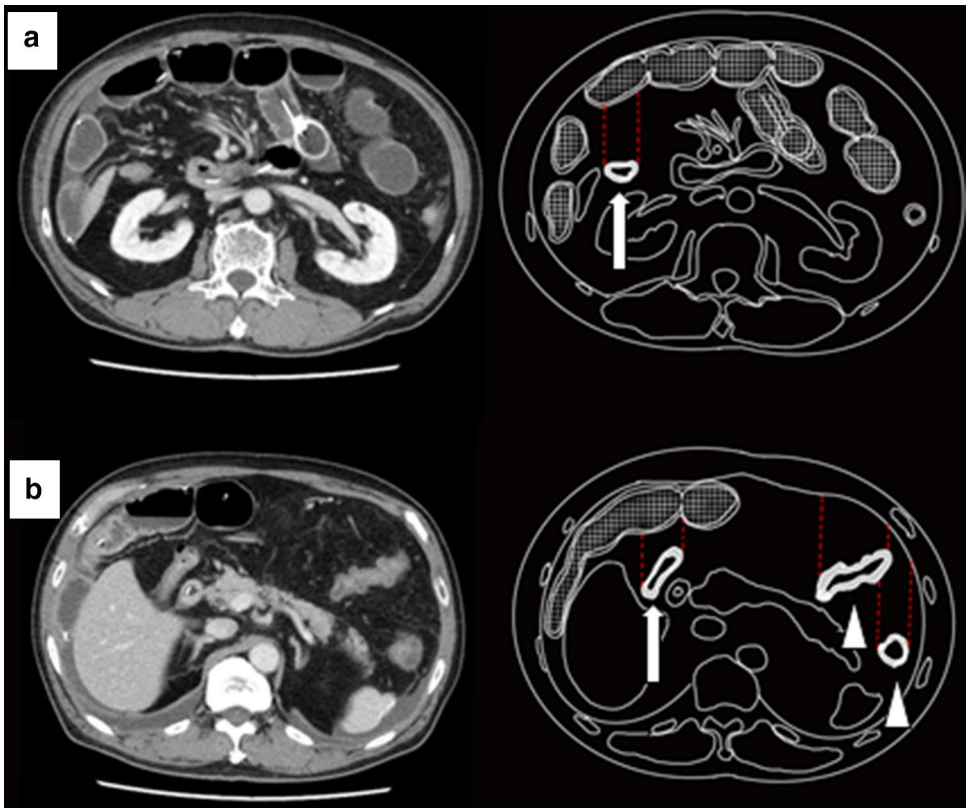

Fig. 1 An example of PTPI calculation. Two axial contrast-enhanced CT images and their schemas are shown (79-year-old man with a transomental hernia; type A). The grid pattern indicates dilated intestinal loops. The white arrows indicate transverse colon loops posterior to dilated small bowel loops. The white arrowheads indicate the transverse colon without anterior small bowel loops. **a** The number of transverse colon loops is 1, and the number of transverse colon loops posterior to dilated small bowel loops is 1. **b** The number of transverse colon loops is 3, and the number of transverse colon loops posterior to dilated small bowel loops is 1. The PTPI was calculated using the number of transverse colon loops posterior to dilated small bowel loops as the numerator and the number of transverse colon loops in whole abdominal CT images as the denominator. *CT* computed tomography, *PTPI* proportion of transverse colon loops posterior to dilated intestinal loops

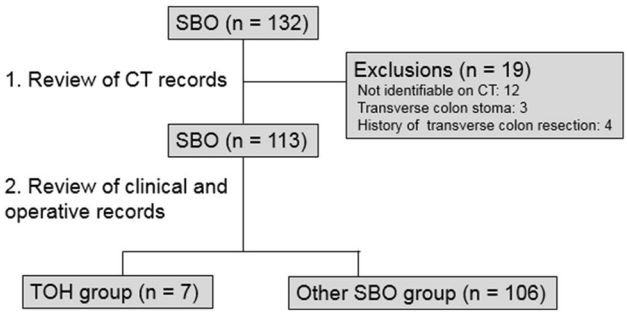

Fig. 2 Patient selection. We reviewed the CT data of 132 SBO patients and excluded 19 patients because of unclear transverse colon images or other issues. We reviewed the clinical and operative records and divided the remaining 113 patients into TOH and other SBO groups. *CT* computed tomography, *SBO* small bowel obstruction, *TOH* transomental hernia

Analysis of CT findings

The PTPI values in the TOH and other SBO groups were charted in a histogram (Fig. 3). The median PTPI was significantly higher in the TOH group than in the SBO group (67% [range, 0–97%] vs. 0% [range, 0–100%], $p = 0.03$, Wilcoxon's test; Table 2). An ROC curve of the PTPI for the preoperative diagnosis of a TOH in our study patients is shown in Fig. 4. The area under the curve was 0.817. When the cutoff was considered as 57%, the sensitivity and specificity of the PTPI for the preoperative diagnosis of a TOH were 71% and 94%, respectively.

Secondary endpoints

The findings of the disease duration, number of patients undergoing intestinal resection, and number of hospital deaths in the two groups are summarized in Table 3. There

Table 1 Characteristics of patients in the TOH and other SBO groups

	TOH group ($n=7$)	Other SBO group ($n=106$)	p value
Male sex	3 (42%)	53 (50%)	1
Age	64 (49–87)	71 (25–96)	0.77
BMI (kg/m^2)	21.1 (17.3–25)	19.5 (14.1–30)	0.42
History of abdominal surgery (yes/no)	1 (15%)/6 (85%)	78 (74%)/28 (26%)	0.03
Surgical diagnosis	Transomental hernia Yamaguchi classification Type A: 6; type C: 1	Transmesenteric hernia: 5 Paracecal hernia: 1 Broad ligament hernia: 1 Inguinal hernia: 4 Femoral hernia: 2 Obturator hernia: 3 Umbilical hernia: 2 Incisional hernia: 1 Adhesive SBO: 66 Peritoneal metastasis: 5 Small intestine carcinoma: 1 Small bowel volvulus: 11 Ladd ligament: 1 Intussusception: 1 Bezoar: 1 Foreign bodies: 1	

Data are presented as median (minimum–maximum), number (percentage), or number

TOH transomental hernia, *SBO* small bowel obstruction, *BMI* body mass index

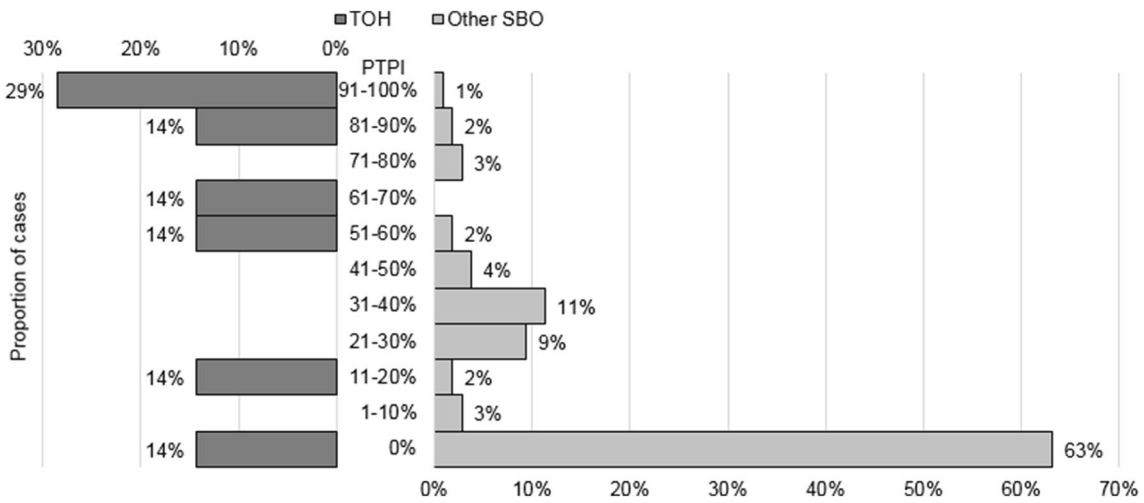

Fig. 3 A histogram of the PTPI in the TOH and other SBO groups. Among patients with TOHs, 71% show displacement of the transverse colon (PTPI of > 50%), and among those with other SBOs, 92% show no displacement of the transverse colon (PTPI of ≤ 50%). *PTPI* proportion of transverse colon loops posterior to dilated intestinal loops, *SBO* small bowel obstruction, *TOH* transomental hernia

Table 2 Comparison of the proportion of transverse colon loops posterior to dilated small bowel loops between the TOH and other SBO groups

	TOH group ($n=7$)	Other SBO group ($n=106$)	p value	
Proportion of transverse colon loops posterior-to-dilated small bowel loops (%)	67 (0–97)	0 (0–100)	0.03	< 0.05

Data are presented as median (minimum–maximum)

TOH transomental hernia, *SBO* small bowel obstruction

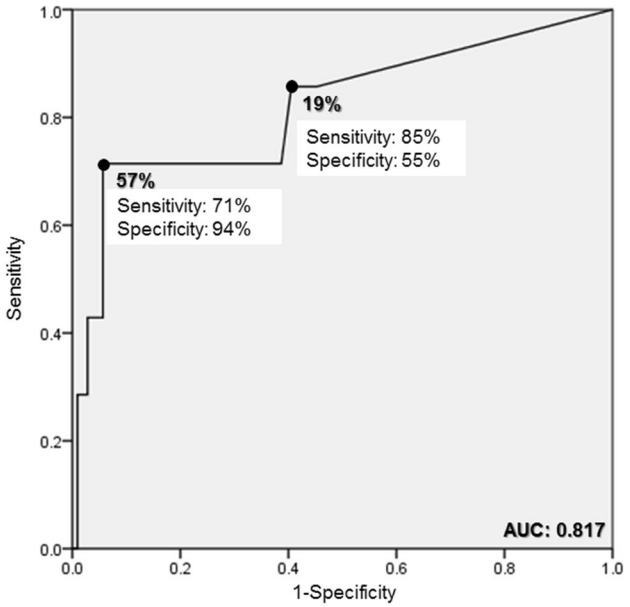

Fig. 4 A receiver operating characteristic curve for TOH detection using the PTPI. When the PTPI is ≥57%, the sensitivity is 71% and specificity is 94%. When the PTPI is ≥19%, the sensitivity is 85% and specificity is 55%. The area under the curve (AUC) is 0.817. *PTPI* proportion of transverse colon loops posterior to dilated intestinal loops, *TOH* transomental hernia

were no statistically significant differences in these endpoints between the two groups.

Discussion

In our study, the incidence rate of a TOH was 5% among surgical SBO cases, and it was higher than that reported in previous studies [1, 6]. Type A is considered the major type of TOH (85%), according to a Japanese study involving 203 TOH cases [14]. The rate of intestinal resection was 28% in our series, which is slightly lower than the rate of 38% reported in this previous study [14]. It is assumed that a short disease duration and early surgery can prevent intestinal strangulation. In our series, the disease duration of patients in the TOH group was 8 h, and it was shorter than that of patients in the other SBO group, although the difference was not significant. Two patients with a TOH received conservative care for 1 week before undergoing elective surgery. Fortunately, these two patients were successfully managed without the development of strangulation.

Several CT findings, including the whirl sign (characterized by swirling and stretching of the mesentery), the beak sign (characterized by a triangular formation created by closely apposed small bowel loops inside the intraperitoneal hernial ring), a cluster of dilated small bowel loops, the intestinal infarction sign, and displacement of the ascending colon and cecum medially and posteriorly, have been reported as characteristic signs of a TOH [3, 14]. However, their diagnostic performances were not known. The preoperative diagnosis of a TOH is difficult, and preoperative diagnosis was reported in only 9% of 203 TOH cases in a previous Japanese study [15]. A type-C TOH is detected preoperatively relatively often, with CT demonstrating the obstructed small bowel in the omental bursa [16, 17]. On the other hand, a type A TOH, which is the most common type, may have no specific CT findings.

In a previous Japanese study, among 24 TOH cases, 23 (96%) had displacement of the transverse colon [10]; however, this report did not present detailed methods for the preoperative diagnosis of a TOH according to CT findings. We attempted to quantify displacement of the transverse colon by counting the number of loops in axial CT slices. We found that 71% of TOH patients had a PTPI over 50%, while 92% of other SBO patients had a PTPI less than 50% (Fig. 3). However, there were atypical cases in these patient groups. In the TOH group, two patients did not show displacement of the transverse colon (PTPI of 0% and 20%). These two patients had a dilated small bowel and hernial orifice in the pelvis. As a dilated small bowel is distant from the transverse colon in the craniocaudal direction, they were not shown in the same axial CT image (Fig. 5a). In the other SBO group, one patient showed displacement of the transverse colon (PTPI of 97%). This patient had a dilated small bowel in the entire peritoneal cavity (Fig. 5b). The intraoperative diagnosis was multiple stenoses of the small bowel with peritoneal metastasis of gastric cancer, and the dilated small bowel extended even cranial to the liver. Pathological

Table 3 Comparison of the disease duration, number of intestinal resections, and number of hospital deaths between the TOH and other SBO groups

	TOH group ($n=7$)	Other SBO group ($n=106$)	p value
Disease duration[a] (h)	8 (2–195)	45 (1–1080)	0.41
Number of intestinal resections	2 (28%)	37 (35%)	1
Number of hospital deaths	0 (0%)	4 (3.7%)	1

Data are presented as median (minimum–maximum) or number (percentage)

TOH transomental hernia, *SBO* small bowel obstruction

[a]Disease duration is the time from the first hospital visit to surgery

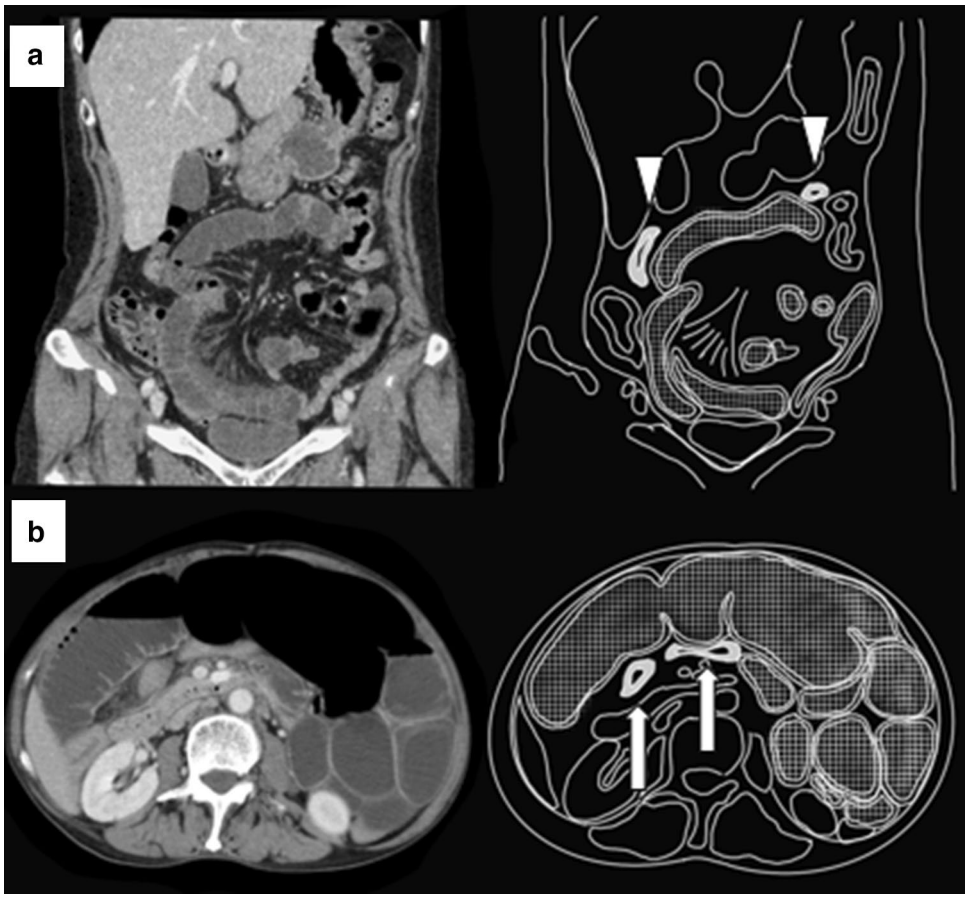

Fig. 5 Atypical cases. The grid pattern indicates dilated intestinal loops. The white arrows indicate transverse colon loops posterior to dilated small bowel loops. The white arrowheads indicate the transverse colon without anterior small bowel loops. **a** Coronal contrast-enhanced CT image and its schema are shown (63-year-old woman with a transomental hernia; type A). Dilated small bowel loops and a hernial orifice are noted in the pelvis. The dilated small bowel loops are distant from the transverse colon in the craniocaudal direction. **b** Axial contrast-enhanced CT image and its schema are shown (72-year-old man with peritoneal metastasis of gastric cancer). Dilated small bowel loops are in the entire peritoneal cavity. *CT* computed tomography

conditions affecting the entire length of the small intestine would show similar CT findings, and they should be considered in the differential diagnosis of a high PTPI.

There were 12 patients with an unidentifiable transverse colon and no TOH cases were included in these cases. Seven patients had an unclear thin transverse colon (emaciation), a marked dilated small intestine, or non-contrast CT images. Three patients had only pelvic axial CT images (the transverse colon was not shown). Two patients had an unclear transverse colon owing to halation of the contrast medium and intestinal tube. We could not use the PTPI for patients in whom the transverse colon was not clearly identified in CT images.

We additionally performed a sub-analysis on the reproducibility of the PTPI with two additional PTPI scorings by two reviewers (Authors T.K. and K.M.). Each of the two also analyzed a different set of 10 randomly selected other SBO cases in addition to the seven TOH cases. Although the PTPI varied widely in one TOH case (Author R.I., 81%; Author T.K, 75%; Author K.M., 9%) and 1 other SBO case (Author R.I., 22%; Author T.K., 68%), the PTPI values calculated by the different interpreters were generally concordant in the remaining cases (data not shown). The PTPI appears to be free from subjectivity in most SBO cases; however, its utility might be limited in a small proportion of cases in which the transverse colon is markedly collapsed and unclear in axial CT images.

The present study had some limitations, including a retrospective study design and a limited number of study patients. Therefore, further prospective studies are required to verify the usefulness of the PTPI for the preoperative diagnosis of a TOH. Nonetheless, the ROC curve of the PTPI in the current study showed that the PTPI could be a novel and reliable approach for the preoperative diagnosis of a TOH.

In conclusion, our results suggest that the CT finding of displacement of the transverse colon posterior to obstructed intestinal loops is characteristic of a TOH and that the PTPI is a reliable quantitative measure to distinguish a TOH from other types of SBOs.

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Compliance with ethical standards

Conflict of interest All authors have no conflicts of interest to declare.

Ethical approval All procedures performed were in accordance with the ethical standards of the institutional and/or national research com-

mittee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Our institutional review board approved this retrospective study.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Ghiassi S, Nguyen SQ, Divino CM, Byrn JC, Schlager A. Internal hernias: clinical findings, management, and outcomes in 49 nonbariatric cases. J Gastrointest Surg. 2007;11:291–5.
2. Lee SH, Lee SH. Spontaneous transomental hernia. Ann Coloproctol. 2016;32:38–41.
3. Andrea A, Tran V, Schmidt CK, Fisahn C, Iwanaga J, Oskouian RJ, et al. Internal hernia of the greater omentum: cadaveric findings of a previously unreported variant. Cureus. 2017;9:e1294.
4. Binns PM. Intestinal obstruction due to spontaneous transomental hernia with previous radiological evidence of the presence of the hernia. Br J Clin Pract. 1962;16:213–4.
5. Yamaguchi T. A case of incarceration of sigmoid colon into hiatus of greater omentum. Rinsho Geka. 1978;33:1041–5.
6. Inukai K, Takashima N, Miyai H, Yamamoto M, Kobayashi K, Tanaka M, et al. Two patients with spontaneous transomental hernia treated with laparoscopic surgery: a review. J Surg Case Rep. 2018;2018:rjy070.
7. Hull JD 3rd. Transomental hernia. Am Surg. 1976;42:278–84.
8. Delabrousse E, Couvreur M, Saguet O, Heyd B, Brunelle S, Kastler B. Strangulated transomental hernia: CT findings. Abdom Imaging. 2001;26:86–8.
9. Le Moigne F, Lamboley JL, de Charry C, Vitry T, Salamand P, Farthouat P, et al. An exceptional case of internal transomental hernia: correlation between CT and surgical findings. Gastroenterol Clin Biol. 2010;34:562–4.
10. Imaeda M, Ishikawa A, Ogiso S, Sakaguchi K, Koumura T, Koike Y. A case of transomental hernia: usefulness of MDCT-MPR for the diagnosis (in Japanese with English abstract). Nihon Fukubu Kyukyu Igakkai Zasshi. (J Abdom Emerg Med.). 2013;33:871–4.
11. Kawasaki A, Mimatsu K, Oida T, Fukino N, Kuboi Y, Kano H, et al. A case of strangulation obstruction due to transomental hernia preoperatively diagnosed by abdominal computed tomography (in Japanese with English abstract). Nihon Gekakei Rengo Gakkaishi (J Jpn Coll Surg). 2009;34:1126–30.
12. Chou CK, Mak CW, Wu RH, Chang JM. Combined transmesocolic–transomental internal hernia. Am J Roentgenol. 2005;184:1532–4.
13. Thompson WM, Kilani RK, Smith BB, Thomas J, Jaffe TA, Delong DM, et al. Accuracy of abdominal radiography in acute small-bowel obstruction: does reviewer experience matter? Am J Roentgenol. 2007;188:233–8.
14. Camera L, De Gennaro A, Longobardi M, Masone S, Calabrese E, Del Vecchio W, et al. A spontaneous strangulated transomental hernia: prospective and retrospective multi-detector computed tomography findings. World J Radiol. 2014;6:26–30.
15. Kimura Y, Iwakawa K, Nishie M, Inagaki M, Iwagaki H. A case of strangulated ileus caused by transomental hernia with reference to previously reported cases (in Japanese with English abstract). Okayama Igakkai Zasshi (J Okayama Med Assoc). 2012;124:149–53.
16. Ariyarathenam AV, Tang TY, Nachimuthu S, Koak Y, Harris AM. Transomental defects as a cause of chronic abdominal pain, the role of diagnostic laparoscopy: a case series. Cases J. 2009;2:8356.
17. Ishigami S, Natsugoe S, Ojiro M, Aikou T. A case of trans-omental hernia: an incarcerated bowel condition detected by computed tomography. Dig Surg. 2000;17:173–4.