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ORIGINAL ARTICLE – COLORECTAL CANCER

Age, Preoperative Subcutaneous Fat Area, and Open Laparotomy are Risk Factors for Incisional Hernia following Colorectal Cancer Surgery

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ABSTRACT

Background. Although incisional hernia (IH) is a common complication of abdominal surgery, the incidence rate and risk factors are not well known. The objectives of this study are to determine the incidence rate of IH following colorectal cancer surgery and to describe the associated risk factors.

Methods. Between 2005 and 2010, patients who underwent surgery to treat colorectal cancer were examined. The diagnosis of IH was performed by CT scan, and the visceral fat area (VFA) and subcutaneous fat area (SFA) at the level of the umbilicus were calculated using a 3D-image analysis system. Survival analysis was used to assess the incidence and risk factors of IH.

Results. A total of 626 patients (326 open, 300 laparoscopic) were included in this study, with median follow-up of 54 (range 2–97) months. Forty patients were diagnosed with postoperative IH, and the cumulative, 5-year incidence of IH was 7.3 %. Univariate analysis revealed that age, body mass index, waist circumference, hip circumference, open laparotomy, wound infection, VFA, and SFA were significantly associated with incidence of IH. Multivariate analysis revealed that age [hazard ratio (HR) 1.043 (1.005–1.083), $p = 0.027$], open laparotomy [HR 4.410 (1.018–19.095), $p = 0.047$], and SFA [HR 1.013 (1.004–1.022), $p = 0.005$] were significant risk factors for developing IH.

Conclusions. Higher age and SFA, along with open surgery, are risk factors for developing IH.

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Incisional hernia (IH) is one of the common complications following abdominal surgery. The incidence of IH has been reported between 2–20 %;[1,2] however, patients with IH may be asymptomatic, and the incidence of IH may be underestimated, especially in peripherally obese patients.[3–5] Patients who develop IH often suffer from poor body image, abdominal pain, and lower quality of life.[6,7] One study also reported that between 6 and 15 % of IH cases require hernioplasty, due to strangulation or obstructive symptoms.[3] Abdominal CT scanning can improve diagnostic accuracy and may be used to determine a more accurate incidence rate of IH.[3–5]

The risk factors for IH include: choice of surgical procedure,[6] wound infection,[7–9] obesity,[8–10] male sex,[9] and acute surgery.[11] Wound infection, and the localized inflammation, may directly affect postoperative healing. As well, excessive adipose tissue in obese patients may interfere with the completion of the appropriate surgical procedure, increasing the likelihood of various postoperative complications.[12,13] The evidence suggests that the influence of clinical and technical factors may be intricately linked to the development of IH. However, the risk factors for IH have not yet been validated, because there is a lack of available evidence. Therefore, finding methods for the prevention and treatment of IH should be considered a priority. In this study, we describe the incidence rate of IH in the era of laparoscopic colorectal surgery and clarify the risk factors for postoperative development of IH in patients with colorectal cancer.

PATIENTS AND METHODS

Study Design and Patients

Between September 2005 and December 2010, 811 patients with colorectal cancer underwent surgery in our institution. Among these patients, 626 patients who

underwent pre- and postoperative whole-body computed tomography (CT) scanning were included in this study. Postoperative CT scans were conducted every 6 months to monitor for recurrence until 5 years after surgery. This case–control study was approved by the institutional review board of Keio University School of Medicine.

Outcome of Interest

The primary endpoint was defined as any postoperative incidence of IH during the evaluation period. IH was retrospectively diagnosed by CT scan when discontinuity in the abdominal fascia was observed; diagnosis also required an observation that fat, peritoneum, or bowel had breached the surgical incision site. Two investigators (TY and KO) provided independent diagnoses of IH; any disagreement regarding diagnosis was discussed and agreement reached by consensus. Parastomal hernia was not included as an outcome of interest, because the etiology is considered distinct from that of IH.

Data Extraction

We retrospectively extracted data from patient charts, including age, sex, height, weight, body mass index (BMI), hip circumference, waist circumference, staging of cancer, operative procedure, operative time, blood loss, location of incision, and postoperative complications. Patients who underwent open surgery and those who were converted to open surgery due to surgical complications were analyzed together as the open surgery group. Analysis of the preoperative CT scan to determine SFA and VFA at the level of the umbilicus was performed using the Synapse VINCENT image analysis system (Fujifilm Medical, Tokyo, Japan), which is implemented as a plug-into the processing workstation (Fig. 1).

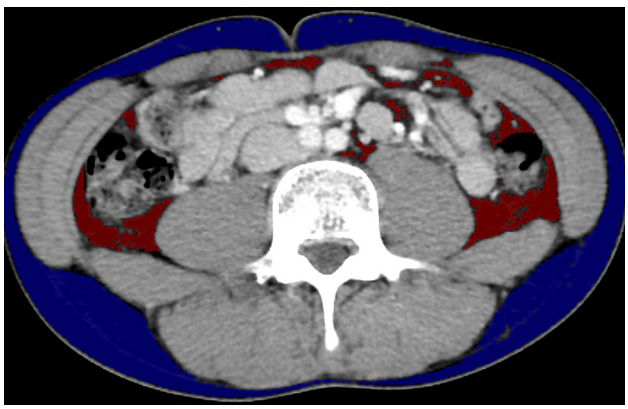

FIG. 1 Measurement of visceral fat area (VFA) and subcutaneous fat area (SFA). Measured VFA (*red*) and SFA (*blue*) at the level of the umbilicus

Statistical Analysis

Median and interquartile range (IQR) values were presented for continuous variables. The cumulative incidence of IH during the evaluation period was assessed using the Kaplan–Meier method. Deaths during follow-up, and any losses to follow-up without previous IH, were considered as censored observations. The Cox proportional-hazards model was used to quantify the influence of individual covariates on IH, whereby hazard ratios (HRs) and confidence intervals (CIs) were calculated. Covariates with $p < 0.1$ in univariate Cox models were included in further multivariate Cox models. The prognostic value of IH also was evaluated in a fractional polynomial model. All statistical tests were two-sided, and the significance level was set at 0.05. All statistical analyses were performed using Stata 12 software (Stata Corporation, College Station, TX).

RESULTS

Of 811 colorectal cancer patients who underwent surgery, 626 were included in this study (364 men, 262 women). The median age of these patients was 67 years at the time of operation. Median BMI was 22.60 kg/m^2, median SFA was 113.64 cm^2, and median VFA was 89.15 cm^2. Open surgery was used in 326 cases, and laparoscopic surgery was used in 300 cases. Fourteen procedures began as laparoscopic operations and were subsequently converted to open surgery, due to surgical complication. The median follow-up period was 54 months (Table 1).

Incidence of Incisional Hernia

Forty patients developed IH following surgery. Of these, 19 patients (47.5 %) developed IH within the first postoperative year, and 15 patients (85 %) developed IH during the second postoperative year. Among the 40 patients who developed IH, 32 patients underwent open surgery, and eight patients underwent laparoscopic surgery. In the 14 cases of conversion from laparoscopic to open surgery, only one patient developed IH. The cumulative incidence of IH is shown in Fig. 2, and the 5-year cumulative incidence rate was found to be 7.3 % [0.902–0.947].

As shown in Table 2, univariate analysis found that older age, higher BMI, larger waist and hip circumference, higher SFA, higher VFA, wound infection (worse than Grade 2 using Clavien–Dindo classification), large midline incision, and open surgery significantly increased the risk of developing IH. Multivariate analysis found higher age and SFA, as well as open surgery, to be significant risk factors. It revealed that every increase of 10 cm^2 SFA increases the hazard ratio of IH by 12 %. To identify the

TABLE 1 Patients' demographics

	IH − [$N = 586$]	IH + [$N = 40$]	p
Age, median (IQR)	67 [16 (58–74)]	72.5 [10.5 (66–76.5)]	0.007‡
Sex (male/female)	346/240	18/22	0.081†
Height (m), median (IQR)	1.62 [0.14 (1.55–1.68)]	1.58 [0.10 (1.54–1.64)]	0.071‡
Weight (kg), median (IQR)	59.0 [16.8 (51.0–67.8)]	61.8 [13.8 (53.2–67.0)]	0.224‡
BMI (kg/m^2), median (IQR)	22.52 [4.24 (20.41–24.65)]	23.76 [4.13 (22.10–26.23)]	0.003‡
Waist (cm), median (IQR)	82 [14 (74–89)]	87 [5 (79–94)]	<0.001‡
Hip (cm), median (IQR)	90 [8.5 (85.5–94)]	92 [9 (90–99)]	<0.001‡
SFA (cm^2), median (IQR)	110.55 [72.07 (76.93–149.00)]	87.09 [117.77–204.86]	<0.001‡
VFA (cm^2), median (IQR)	86.53 [80.28 (46.02–126.30)]	95.51 [92.45 (67.78–160.23)]	0.035‡
Stage (I/II/III/IV)	186/172/149/79	6/14/14/6	0.121†
Open/laparoscopic	292/294	8/32	<0.001†
OT (min), median (IQR)	225 [114 (180–294)]	205 [98 (172–270)]	0.246‡
Bleeding (mL), median (IQR)	50 [190 (10–200)]	111 [181 (43–224)]	0.025‡
Wound infections	25	6	0.010†

IH incisional hernia, *IQR* interquartile range, *BMI* body mass index, *SFA* subcutaneous fat area, *VFA* visceral fat area, *OT* operation time

† χ^2 test or Fisher's exact test, two-sided

‡ Wilcoxon rank-sum test

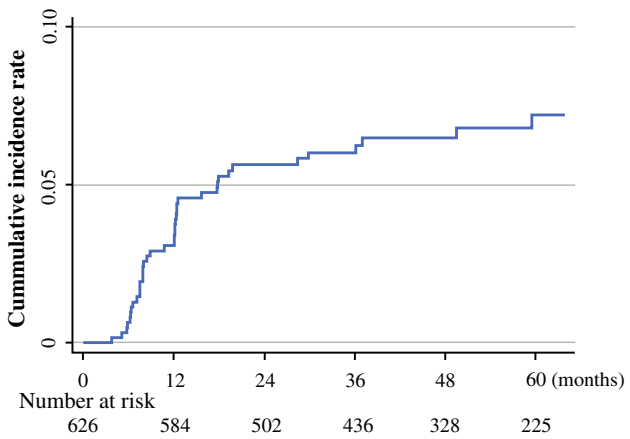

FIG. 2 Cumulative incidence rate curve for incisional hernia

correlation between the increment of SFA and the risk of developing IH, a fractional polynomial test analysis was conducted (Fig. 3). The figure shows that the hazard ratio of developing IH increased exponentially with increasing SFA.

DISCUSSION

Our findings indicate that development of IH after colorectal cancer resection was influenced by higher age and SFA, as well as open surgery. These results suggest that the etiology of IH involves the patient's clinical characteristics, as well as the chosen surgical approach. For elderly colorectal cancer patients, poor nutritional status and sarcopenia are frequently observed, and these may be linked to the increase risk of developing IH. Armstrong et al.[14] and Mäkelä et al.[15] have previously reported the relationship between poor nutritional status (indicated by hypoalbuminemia) and wound dehiscence. It has been proposed that age-related changes in the composition of interstitial collagen may affect IH formation.[16] Together, these age-related physiological changes may provide one etiological mechanism for the development of IH.

Another etiological mechanism may be linked to the type of fat deposits in obese patients. In these patients, the location of excess adipose tissue can be classified as subcutaneous or visceral. Previous data have not been able to link specifically IH development to subcutaneous or visceral fat, although our results clearly indicate that subcutaneous (quantified by SFA), and not visceral (quantified by VFA), adipose tissue is the risk factor for IH development. These findings suggest that a physical impediment due to excessive subcutaneous tissue impairs the closure of the abdomen and plays a more important role than any increased intra-abdominal pressure caused by excessive visceral tissue. However, to better understand the incidence of and to establish a protective strategy for IH, further studies controlling these clinical covariates should be conducted.

In addition to aging and SFA, open colorectal surgery was significantly associated with an increased incidence of IH. One explanation for the difference in incidence of IH between open and laparoscopic surgery may simply be the shorter length of incision.

Both Duepree et al.[17] and Andersen et al.[18] have previously reported a significantly higher incidence of IH in

TABLE 2 Univariate and multivariate analysis of risk factors for the development of IH following colorectal cancer surgery

Factors	Univariate HR (95 % CI)	*p*	Multivariate HR (95 % CI)	*p*
Age	1.044 (1.014–1.075)	0.004	1.043 (1.004–1.083)	0.032
Female	1.692 (0.908–3.156)	0.098	1.251 (0.382–4.098)	0.711
Height	0.056 (0.002–1.390)	0.079	1.799 (0.004–719.316)	0.848
Weight	1.019 (0.993–1.046)	0.147		
BMI	1.152 (1.071–1.240)	<0.001	0.922 (0.745–1.140)	0.453
Waist	1.060 (1.031–1.089)	<0.001	1.012 (0.949–1.078)	0.722
Hip	1.078 (1.034–1.123)	<0.001	1.018 (0.937–1.106)	0.670
Stage				
I	1 (reference value)		1 (reference value)	
II	2.417 (0.929–6.291)	0.070	0.987 (0.343–2.839)	0.981
III	2.900 (1.114–7.547)	0.029	1.588 (0.569–4.432)	0.378
IV	2.660 (0.857–8.262)	0.091	1.616 (0.485–5.380)	0.434
OT	0.999 (0.995–1.002)	0.355		
Bleeding	1.000 (0.999–1001)	0.630		
Open	3.998 (1.842–8.679)	<0.001	4.628 (1.047–20.463)	0.043
Type of incision				
Transverse	1 (reference value)		1 (reference value)	
Midline	6.151 (0.845–44.775)	0.073	3.119 (0.347–28.016)	0.310
Length of incision				
Mid 1/3	1 (reference value)		1 (reference value)	
Lower 1/3	0.714 (0.207–2.467)	0.595	1.096 (0.293–4.098)	0.891
Larger than 2/3	2.604 (1.010–6.713)	0.048	0.696 (0.147–3.295)	0.648
Wound infection	3.648 (1.531–8.689)	0.003	2.234 (0.862–5.786)	0.098
VFA	1.007 (1.002–1.011)	0.005	1.001 (0.992–1.009)	0.902
SFA	1.011 (1.008–1.015)	<0.001	1.012 (1.003–1.021)	0.007

CI confidence interval, *HR* hazard ratio, *BMI* body mass index, *VFA* visceral fat area, *SFA* subcutaneous fat area, *OT* operation time

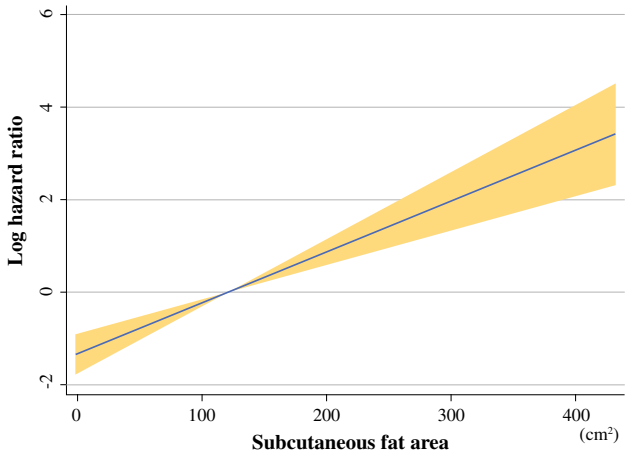

FIG. 3 Correlation between subcutaneous fat area and incidence of incisional hernia. *Orange area* reveals 95 % confidence interval

open bowel resection, and several studies have reported a positive relationship between the length of incision and development of IH.[8,19] A lower incidence rate for IH following laparoscopic surgery for colorectal disease also has been reported.[17,18] In contrast, several randomized, controlled trials and meta-analyses have not found laparoscopic colorectal surgery to reduce the risk of developing IH.[20,21] The discrepancies in the available evidence should be considered in light of the technical difficulties associated with the small incisions used in laparoscopic surgery. In some cases, it may be difficult to properly seal the incision, which may explain the finding that the incidence of IH after laparoscopic colorectal surgery was similar to that of open surgery.

In the present study, only 1 of the 300 laparoscopically treated patients developed a port-site hernia, which had a trocar diameter of 12 mm. As previously reported, the incidence of port-site hernias is very low[22], and there is minimal difference between operative procedures (colorectal surgery, 0.6 %;[23] colectomy, 0.9 %;[24] Roux-en-Y gastric bypass, 0.3 %[25]). However, a positive relationship between the development of port-site hernia and trocar diameter has been described; Montz et al. reported that 86.3 % of port-site hernias occurred in sites with a trocar diameter of ≥10 mm.[26]

The method of abdominal fascia closure also may be an important factor etiological factor in the development of IH. Hodgson et al.[2] reported that a continuous, nonabsorbable suture significantly lowered the incidence of IH compared with an interrupted or absorbable suture. Although sutures with an antibacterial coating may reduce the incidence of IH, there is no clear evidence to support this interpretation.[27] In contrast, the stitch length (SL) to wound length (WL) ratio is considered an important parameter to assess the quality of the suture technique. Millbourn et al.[28] reported that a SL to WL ratio <4 is a significant risk factor for developing IH (OR 3.73). Despite an accumulating base of evidence, the optimal abdominal closure has not yet been established and remains an important topic for future research.

There are some limitations in this study. First, our study was retrospective and observational and may be prone to selection bias. Although operative procedures were chosen during institutional multidisciplinary meetings, open surgery is likely to be chosen for obese patients, patients with advanced cancer, and patients with poor general condition given the difficulties of laparoscopic surgery in these patients. Second, the quality of abdominal fascia closure may have varied between cases. Although we closed abdominal fascia using slowly absorbable sutures, it is difficult to assess retrospectively the quality of the fascia suture using the SL to WL ratio. A well-controlled study, in which fascia closure quality is standardized, may provide more robust evidence regarding the incidence of IH after colorectal resection.

In conclusion, after colorectal cancer surgery, higher age and SFA, as well as open surgery, are significant risk factors for developing IH. In patients who exhibit these characteristics, or who undergo open surgery, appropriate measures should be taken to prevent IH.

DISCLOSURE The authors declare no commercial or competing interests.

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