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ORIGINAL ARTICLE

A low subcutaneous fat mass is a risk factor for the development of inguinal hernia after radical prostatectomy

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Abstract

Purpose Inguinal hernia (IH) after radical prostatectomy (RP) is a complication that impairs quality of life; however, the factors contributing to IH after RP remain unclear. Therefore, we herein attempted to identify the factors responsible for the development of IH after RP.

Methods We reviewed 622 patients who underwent laparoscopic or robot-assisted laparoscopic RP at our hospital between December 2011 and April 2020. The total fat area and visceral fat area were calculated at the level of the umbilicus using computed tomography, and the subcutaneous fat area (SFA) was calculated by subtracting the visceral fat area from the total fat area. The psoas muscle area was measured at the third lumbar vertebrae level using computed tomography to calculate the psoas muscle mass index, which is used in sarcopenia as an index of muscle mass. We investigated the risk factors for IH after laparoscopic or robot-assisted laparoscopic RP.

Results IH developed in 88 patients (16.7%). Fifty-seven of these patients underwent hernia repair at our hospital, and 56 (98.2%) had indirect hernias. A multivariate analysis identified SFA (odds ratios: 0.383, $p < 0.001$) as an independent predictor for the development of IH. Two-year IH-free survival rates were 77.3% in the small SFA group (SFA < 123 cm^2) and 88.7% in the large SFA group (SFA ≥ 123 cm^2) ($p < 0.001$).

Conclusion Subcutaneous fat was associated with the development of IH, particularly indirect IH, after laparoscopic or robot-assisted laparoscopic RP. An indirect IH prevention technique needs to be considered, particularly for patients with less subcutaneous fat.

Keywords Inguinal hernia · Prostate cancer · Radical prostatectomy · Subcutaneous fat mass

Introduction

Prostate cancer is the most common cancer in men, and radical prostatectomy (RP) is one of the standard treatments that is widely performed for localized prostate cancer [1]. Urinary incontinence and erectile dysfunction are well-known complications of RP, whereas inguinal hernia (IH) is not. IH after RP was initially reported by Regan et al. in 1996, and occurred in 13.7% of patients after open RP, 7.5% after laparoscopic RP (LRP), and 7.9% after robot-assisted laparoscopic RP (RALP) [2, 3]. The mechanisms underlying the development of IH after RP have not yet been elucidated, and contributing factors, such as the presence of patent processus vaginalis (PPV), a low body mass index (BMI), dysuria, sarcopenia, an extraperitoneal approach, and thin external oblique muscle, were identified in previous studies [4–10]. A relationship with low BMI has also been reported for IH regardless of RP; however, the underlying mechanisms remain unknown [11–14]. Low BMI was the most frequently reported independent risk factor for IH after RP in 4 studies. The factors contributing to low BMI are fat and muscle, with either or both of these factors exerting an effect. Regarding muscle mass, a previous study implicated sarcopenia in the development of IH and we measure the psoas muscle mass index (PMI) as an index of sarcopenia [10, 15]. The purpose of the present study was to clarify risk factors for and the mechanisms underlying the development of IH by measuring the subcutaneous fat area (SFA), visceral fat area (VFA), and PMI.

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Materials and methods

Patient selection and data collection

We reviewed 622 patients who underwent RALP or LRP at our hospital between December 2011 and April 2020. Ninety-four patients were excluded: 69 with a postoperative follow-up of less than 300 days, 9 who underwent bilateral IH surgery, and 16 on whom computed tomography (CT) was not performed at our hospital. The median follow-up period in the present study was 46.4 months (range, 10.1–110.2). IH was diagnosed by a physical examination by a gastrointestinal surgeon. We examined parameters that were assumed to be relevant in previous studies, such as age, BMI, prostate-specific antigen, prostate volume, previous abdominal surgery, the surgical approach, operative time, and nerve sparing, measured the thickness of the rectus muscle (TRM), SFA, VFA, and the psoas muscle area, and calculated PMI. LRP was performed via an extraperitoneal approach, and RALP by a transperitoneal approach, except for patients with glaucoma, cerebral aneurysm, or strong peritoneal adhesions.

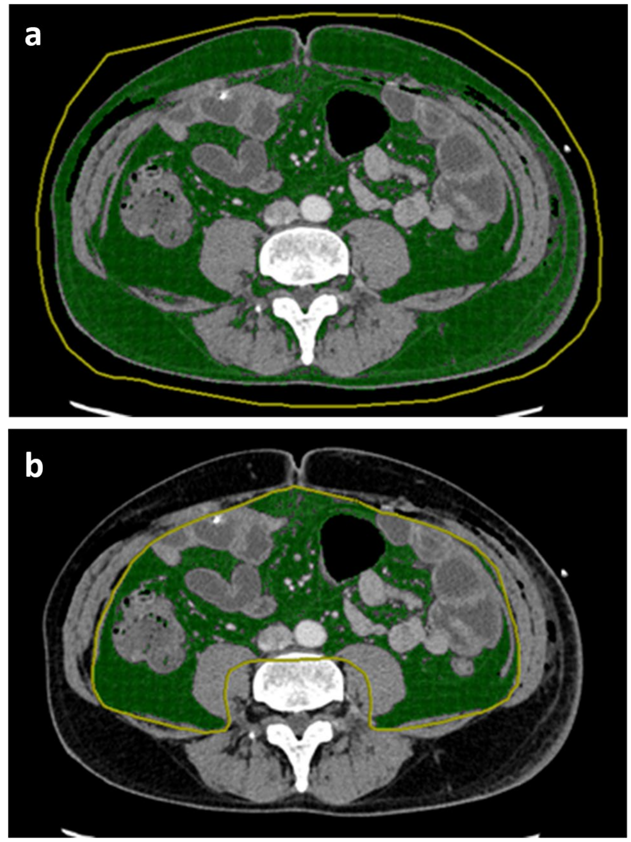

Fig. 1 Measurement of the green area surrounded by the yellow line in CT. **a** Measurement of the total fat area (TFA). **b** Measurement of the visceral fat area (VFA)

Area measurements using CT

CT was preoperatively performed for stage evaluations. The AW server (GE Healthcare) was used to measure the area of − 150 HU ~ − 50 HU at the level of the umbilicus, and the total fat area (TFA) and VFA were calculated (Fig. 1) [16]. The measurement of fat area on CT has been established as a practical method with high inter- and intraobserver reproducibility and strong correlation with fat volume [17]. The psoas muscle area was measured at the third lumbar vertebrae (L3) level from 0 to 100 HU, and PMI was calculated by summing the left and right areas of the psoas muscle and dividing by height squared (Fig. 2) [15]. We used PMI as the index of sarcopenia. TRM was measured at the thickest part around the level of the umbilicus.

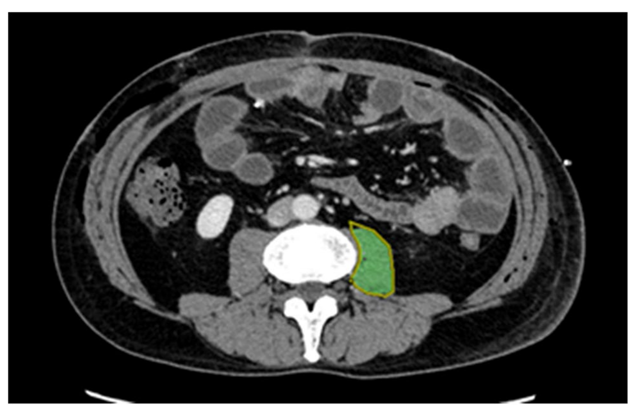

Fig. 2 Measurement of the left psoas muscle area

Statistical analysis

Statistical differences between the groups were examined using the $\chi 2$ test for categorical data and the Mann–Whitney U test for continuous data. The IH-free rate was estimated using a Kaplan–Meier analysis and differences among groups were tested using the Log-rank test. Multiple logistic regressions were used to identify independent predictors of IH. The significance of differences was defined as $p < 0.05$. All statistical analyses were performed using SPSS ver.25 statistical software package (IBM Corp., Armonk, NY, USA).

Table 1 Patient characteristics. All values are median (range) or frequency (proportion)

	Inguinal hernia positive (N = 88; 17%)	Inguinal hernia negative (N = 440; 83%)	*P* value
Age (years)	67 (50–76)	66 (43–78)	0.627
BMI (kg/m^2)	22.9 (15.8–32.4)	23.8 (15.2–37.7)	< 0.001
PSA (ng/ml)	7.00 (2.58–36.8)	6.94 (1.22–56.8)	0.490
Prostate volume (cm^3)	31.9 (12.5–136)	33 (11–103)	0.877
Previous abdominal surgery			0.963
Yes	20 (23%)	99 (23%)	
No	68 (77%)	341 (77%)	
Diabetes mellitus			0.108
Yes	7 (8%)	63 (14%)	
No	81 (92%)	377 (86%)	
SFA (cm^2)	104.8 (6.58–277.2)	127.8 (5.30–359.6)	< 0.001
VFA (cm^2)	90.4 (5.54–263.0)	123.1 (5.42–332.6)	< 0.001
PMI (cm^2/m^2)	6.93 (3.99–10.9)	6.86 (2.81–11.1)	0.470
TRM (mm)	10.5 (7.07–16.0)	10.7 (6.35–18.5)	0.872
LRP			0.612
Yes	44 (50%)	233 (53%)	
No	44 (50%)	207 (47%)	
Transperitoneal approach			0.725
Yes	41 (47%)	196 (45%)	
No	47 (53%)	244 (55%)	
Operative time (min)	213 (91–333)	211 (70–459)	0.817
Nerve spearing			0.129
Yes	15 (17%)	108 (25%)	
No	73 (83%)	332 (75%)	

BMI, body mass index; *PSA*, prostate-specific antigen; *SFA*, subcutaneous fat area; *VFA*, visceral fat area; *PMI*, psoas muscle index; *TRM*, thickness of the rectus muscle; *LRP*, laparoscopic radical prostatectomy

Results

IH developed in 88 patients (16.7%). Patient characteristics are shown in Table 1. Among the 528 patients, LRP was performed on 277 and RALP on 251. BMI was significantly lower in patients with than in those without IH (23.8 kg/m^2 vs. 22.9 kg/m^2, $p < 0.001$). There were 119 cases of abdominal surgeries, including 55 cases after appendectomy, 30 cases after unilateral inguinal hernia surgery, 15 cases after cholecystectomy, 8 cases after gastrectomy, and others such as nephrectomy and colectomy. Nerve-sparing surgery was performed more often in the IH-free group (25% vs. 17%, $p = 0.129$). Median SFA and VFA were significantly smaller in the IH group than in the IH-free group (SFA; 104.8 cm^2 vs. 127.8 cm^2, $p < 0.001$, VFA; 90.4 cm^2 vs. 123.1 cm^2, $p < 0.001$). Median PMI and TRM were 6.86 cm^2/m^2 and 10.7 mm, respectively, and did not correlate with the development of IH. In the multivariate analysis, small SFA was the only independent predictor for the development of IH (odds ratio: 0.383, $p < 0.001$) (Table 2). Two-year IH-free survival rates were 77.3% in the small SFA group and 88.7% in the large SFA group by the Kaplan–Meier analysis ($p < 0.001$) (Fig. 3).

Table 2 Multivariate analysis of factors affecting occurrence of inguinal hernia

	Categories	OR	95% CI	*P* value
BMI (kg/m^2)	< 23.6 vs. ≥ 23.6			0.207
SFA (cm^2)	< 123.0 vs. ≥ 123.0	0.383	0.234–0.625	< 0.001
VFA (cm^2)	< 117.5 vs. ≥ 117.5			0.074

OR, odds ratio; *CI*, confidence interval; *BMI*, body mass index; *SFA*, subcutaneous fat area; *VFA*, visceral fat area

Among the 88 patients who developed IH, it was on the right side in 55 (62.5%), and 75 (85.2%) underwent hernia repair surgery. The European Hernia Society (EHS) classification of the 57 patients who underwent surgery at our hospital is shown in Table 3, and 56 (98.2%) were indirect hernias. The EHS classification is as follows: L1 is an indirect hernia with a hernia port of less than 1 finger, L2 is an indirect hernia with a hernia port of more than 1 finger, but

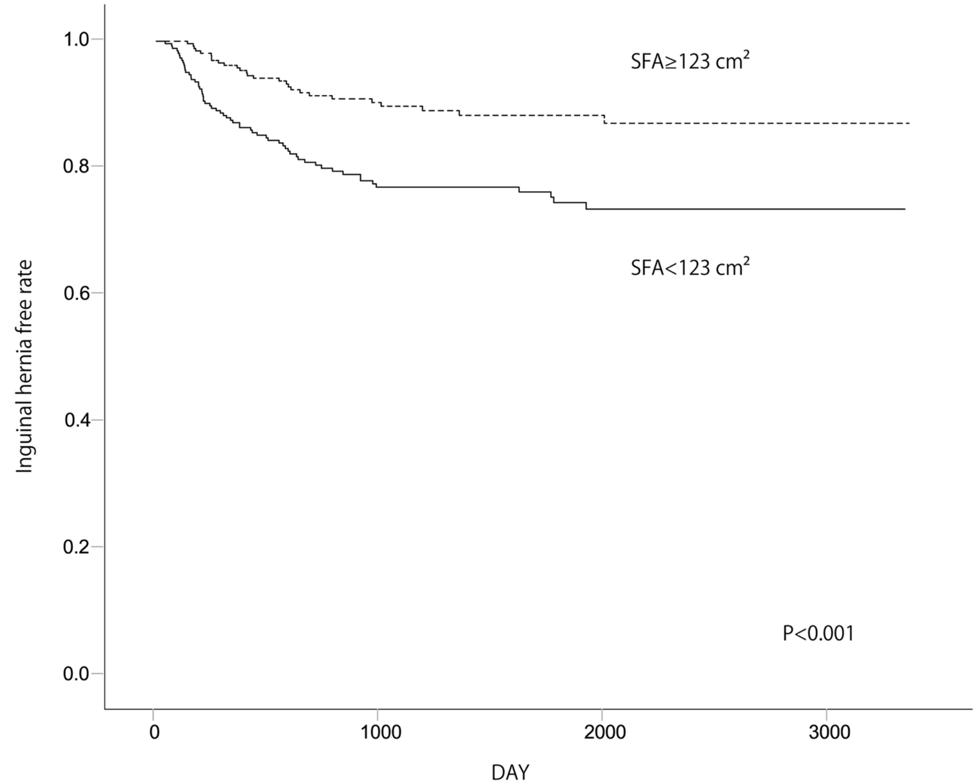

Fig. 3 Kaplan–Meier analysis of the hernia-free rate in SFA ≥ 123 cm^2 and SFA < 123 cm^2 Dotted line indicates SFA ≥ 123 cm^2; straight line, SFA < 123 cm^2

Table 3 Characteristics of patients in whom inguinal hernia developed. All values are median (range)

Interval of inguinal hernia free survival (days)	351 (40–1996)
Hernia side	
Right	55
Left	17
Bilateral	16
EHS classification for groin hernia	
L1. Indirect (lateral) inguinal hernia (hernia port: < 1 finger)	0
L2. Indirect (lateral) inguinal hernia (hernia port: 1–2 fingers)	51
L3. Indirect (lateral) inguinal hernia (hernia port: > 2 fingers)	5
M. Direct (medial) inguinal hernia	1

EHS, European Hernia Society

less than 2 fingers, L3 is an indirect hernia with a hernia port of more than 2 fingers, and M is a direct hernia.

Discussion

IH was previously reported to occur in 13.7% of patients after open RP, 7.5% after LRP, and 7.9% after RALP [3]. Although the development of IH decreased with the shift from open RP to LRP or RALP, it is still common. Most cases of IH require surgery due to pain, discomfort, and the risk of impaction, and it is regarded as a high-grade complication of RP [18]. Hernia repair surgery after RP is challenging due to the development of adhesions [19]. Therefore, urologists need to reduce the risk of IH after RP as well as urinary incontinence and erectile dysfunction [19].

In the present study, we investigated 622 patients who underwent LRP or RALP, and 16.7% developed IH, which was slightly higher than that previously reported [3]. IH is reportedly more common in Asians than in Europeans, which is explained by differences in BMI and muscle mass due to the body composition [10, 20]. Low BMI was identified as a risk factor for IH in several regional studies. Visceral fat and preperitoneal fat are assumed to act as a plug to prevent the onset of disease, and the fat and thickness of the abdominal wall have been proposed to help prevent the development of IH [11–14].

In terms of IH after RP, the most frequently reported risk factor for the development of IH is also low BMI. Other factors, such as psoas muscle volume and external oblique muscle thickness, have been identified [5, 10]. BMI is calculated from height and weight, and weight is affected by both fat and muscle. However, fat and muscle have not yet been examined separately as individual risk factors for the development of IH after RP. The strength of the present study is that we collected CT data from the majority of patients because it is routinely performed before RP at our institution. We measured areas of fat and muscle in detail using CT, and the multivariate analysis identified SFA as the only risk factor for the development of IH after RP. In the presence of PPV, the inguinal canal is connected to the abdominal cavity; however, abdominal viscera do not enter because the internal oblique and transverse muscles have dynamic rather than static defense mechanisms. The transverse muscle has been proposed to close like a shutter, while the internal inguinal ring closes like a sphincter when abdominal pressure rises; although this anatomy was observed in autopsies, it has not yet been clinically proven [21]. Subcutaneous fat may strengthen the transverse fascia and function as a defense mechanism by preventing the development of IH from the internal inguinal ring with a thick abdominal wall [8, 13, 22].

Regarding muscle mass, the multivariate analysis did not select PMI or TRM as risk factors. A previous study measured psoas muscle volume using a 3-dimensional image analysis system and identified a relationship between sarcopenia and the development of IH [10]. In the present study, we used PMI as an index of sarcopenia, and it was not identified as a factor for IH. We also measured TRM as an index of abdominal wall thickness, and it was not associated with the development of IH, which is consistent with previous findings. Another study reported a relationship between the thickness of the external oblique muscle and the development of IH [5]. However, the thickness of this muscle is sensitive to respiratory variations, which are difficult to measure accurately with CT and, thus, this may be a limitation [10].

Among the 88 patients who developed IH, it was on the right side in 55 (62.5%), which is consistent with previous findings showing the development of IH on the right side in two-thirds of cases in the general population. This may be attributed to the asymmetrical anatomy of the sigmoid colon on the left side. The sigmoid colon may play a role in preventing hernia by attaching to the dissected pelvic floor [22, 23]. Among the 57 patients who underwent surgery at our hospital, 56 (98.2%) had indirect hernias, all of which were L2 or greater in the EHS classification, which means that the diameter of the internal inguinal ring was wider than 1 finger. A previous study reported that vesicourethral anastomosis widened the internal inguinal ring due to traction of the peritoneum and vas deferens [4]. Several preventive measures have been proposed to reduce the development of IH, but none have yet been established and may result in longer surgery times. Lee et al. incised the lateral-side internal inguinal floor of PPV, dissected along the spermatic cord, plugged hemostatic agents into the end of the canal, and closed the internal inguinal floor [24]. Shimbo et al. reduced the rate of IH from 19.4 to 2.2% by releasing the vas deferens from the peritoneum a distance of 5 cm with or without cutting the vas deferens to reduce tension to the internal inguinal ring. Since the widening of the inner inguinal ring is considered to be one of the causes of IH, the preventive method by Shimbo et al. appears to be reasonable [4].

Based on the findings described above, patients with a widened internal inguinal ring due to prostatectomy and low subcutaneous fat may develop IH due to the breakdown of defense mechanisms. We need to consider the risk of indirect IH after RP and perform preventive procedures, such as that described by Shimbo et al., particularly for patients with low subcutaneous fat.

There are several limitations that need to be addressed. The present study was not a prospective, randomized controlled study. Furthermore, since our data on the development of IH were collected from medical records, some undetectable IH may have been overlooked. Moreover, details on hernia repair surgeries were only available for patients who underwent surgery at our hospital, and not for those at other hospitals. Further studies on the relationship between the development of IH and fat volume are needed in the future.

Conclusion

Subcutaneous fat is associated with the development of IH. The incidence of IH is higher in patients with less subcutaneous fat, and its prevention needs to be considered in these patients.

Authors' Contributions Study conception and design: KU, TT, YY, NT, RM, HA and MO. Acquisition of data: KU and KH. Analysis and interpretation of data: KU, TT, KM, SM and TK. Drafting of manuscript: KU and TT. Critical revision of manuscript: KM and MO.

Declarations

Conflict of interest The authors declare no competing interests.

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