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Robot-assisted radical prostatectomy may induce inguinal hernia within the first 2 years

An 11-year single-surgeon experience of >400 cases

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Abstract

At present, robot-assisted radical prostatectomy (RARP) is a gold standard in radical prostatectomy. The aim of this study was to evaluate the incidence, risk factors, and timing of occurrence of inguinal hernia (IH) after RARP.

We included 427 patients with prostate cancer who underwent RARP by a single surgeon from February 2006 to August 2017. Incidence, clinical, and pathological factors were investigated to assess relationship with the development of IH.

Postoperative IH occurred in 29 cases (6.79% of all RARP patients), whereas 22 cases (75.9% of all IH patients) occurred within the first 2 years. The median follow-up period was 5.2 years, and the median age of patients was 65 years. Postoperative IH occurrence was significantly associated with body mass index (BMI), smoking history, and low surgeon experience ($P = .036$, .023, and .048, respectively). However, low surgeon experience did not reach statistical significance after multivariate analysis.

The overall incidence of IH after RARP was significantly associated with BMI and smoking history. With obvious incidence of IH within the first 2 years after operation which was not observed at the open prostatectomy, RARP itself may play a role in the development of IH.

Abbreviations: AJCC = American Joint Committee on Cancer, BMI = body mass index, IH = inguinal hernia, IQR = interquartile range, LRP = laparoscopic radical prostatectomy, ORP = open retrospective radical prostatectomy, PPV = patent processus vaginalis, PSA = preoperative prostate-specific antigen, RARP = robot-assisted radical prostatectomy.

Keywords: complication, inguinal hernia, laparoscopy, prostate, radical prostatectomy, robot-assisted laparoscopic surgery

1. Introduction

Prostate cancer is the most common cancer among men in high-income countries and ranks third in terms of mortality after lung cancer and colorectal cancer.[1] Moreover, radical prostatectomy is widely accepted as treatment for local prostate cancer. Postprostatectomy inguinal hernia (IH) was proved to be a complication and can affect the quality of life due to inguinal pain or discomfort. In the past, the estimated incidence of open retrospective radical prostatectomy (ORP) and laparoscopic radical prostatectomy (LRP) was 12.4% to 23.9%[2,3] and 4.9% to 14%,[4–6] respectively. Currently, robot-assisted radical prostatectomy (RARP) is widely used and more commonly performed than ORP and LRP, which accounts for 50% to 70% in the United States.[7–9] In recent years, some studies started to discuss the risk factor of post-RARP IH. However, all articles are multisurgeons, and the duration of the follow-up period was relatively short. Distinguish risk factors from surgeon's experience was difficult. Each study reports different risk factors, and they did not mention the suitable duration of follow-up for IH after RARP. Here, we present an 11 years' experience of a single surgeon performing >400 cases of post-RARP IH and discuss the possible risk factors and ideal follow-up time.

2. Materials and methods

We retrospectively analyzed 427 patients with prostate cancer who had RARP at a tri-service hospital between February 2006 and August 2017. These patients were operated on by the same surgeon. In the standard procedure, the pneumoperitoneal pressure was kept on 12 mm Hg and then elevated to 15 mm Hg when the first trocar was inserted. The pathological stage was performed according to the American Joint Committee on Cancer (AJCC) TNM staging system.[10] Surgeon experience was defined by the number of RARP cases. Standard protocol of follow-ups after discharge was visits at 1 week, 1 month, and every 3 months thereafter. Twenty-nine patients were diagnosed with IH based on their clinical symptoms and on physical examination, but the date of IH occurrence was defined as herniorrhaphy date. The date of RARP was defined as time zero. Informed consent was obtained from all patients.

This study used SPSS statistics version 24 as statistical software for statistical analysis. We used χ^2 test to determine the incidence

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

This article does not contain any studies with human participants or animals performed by any of the authors.

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Table 1

Characteristics of patients undergoing robot-assisted radical prostatectomy (RARP) (N = 427).

Variables		Median value (IQR) or N (%)
Age, y		65 (40–85)
Preop-PSA, ng/mL		10.2 (0.1–298)
Body mass index, kg/m^2		24.80 (16.22–34.95)
History of smoking	No	344
	Yes	83
Diabetes mellitus	Absent	348
	Present	79
Hypertension	Absent	245
	Present	182
HCVD	Absent	344
	Present	83
Operative time, min		225 (143–508)
Prostate weight, g		41 (14–290)
Gleason score	<7	88
	7	249
	>7	90
pT stage	≤pT2	286
	≥pT3	163
Time from RARP to hernia, d	Average (range)	641 (127–2479)
Following time, d	Average (range)	1800 (127–4220)

Preop = preoperative, HCVD = hypertensive cardiovascular disease, PSA = prostate-specific antigen.

of IH and univariate analysis for risk factors such as preoperative factors and comorbidities. Significant factors from univariate analysis were evaluated for multivariate analysis using multiple logistic regression models, and some factors were mentioned as risk factors for IH. The proportion of IH occurrence after RARP was shown through the Kaplan–Meier curve. Statistical significance was defined as P value <.05.

3. Results

A total of 427 patients underwent RARP at our hospital by a single surgeon. Patients' characteristics are shown in Table 1. The basic characteristics such as median age (interquartile range [IQR]: 40–85), preoperative prostate-specific antigen (PSA) level (IQR: 0.1–298), body mass index (BMI) (IQR: 16.22–34.95), smoking history, diabetes mellitus, hypertension, and hypertensive cardiovascular disease were recorded. The operative and disease characteristics such as operative time (IQR: 143–508), prostate weight (IQR: 14–290), Gleason score, pathology T stage, time from RARP to herniorrhaphy (IQR: 127–2479), following time (IQR: 127–4220) were also recorded in Table 1.

Table 2

Features of inguinal hernia (IH) after robot-assisted radical prostatectomy (RARP) (N = 29).

Total		N (%) 29 (100%)
Laterality	Right	19 (65.5%)
	Left	5 (17.2%)
	Bilateral	5 (17.2%)
Type	Indirect	25 (86.2%)
	Direct	2 (6.9%)
	Pantalone	2 (6.9%)
Time from RARP to first herniorraphy	<365 d	12 (41.4%)
	<730 d	10 (34.5%)
	<1095 d	2 (6.9%)
	<1460 d	2 (6.9%)
	≥1460 d	3 (10.3%)

During the observation period, postoperative IH occurred in 29 cases (6.8%) (Table 2). In terms of laterality, the numbers of cases of right, left, and bilateral IH were 19 (65.5%), 5 (17.2%), and 5 (17.2%), respectively. In terms of hernia type, the number of cases of direct, indirect, and pantalone types were 26 (86.2%), 2 (6.9%), and 2 (6.9%), respectively. Furthermore, the number of patients who underwent the first herniorrhaphy <730 (2 years) and ≥730 (2 years) after RARP were 22 (75.9%) and 7 (24.1%), respectively. Kaplan–Meier curves showed the proportion of post-RARP IH-free rates (Fig. 1). The cumulative incidence of post-RARP IH was 2.81% and 5.22% in the first 2 years after

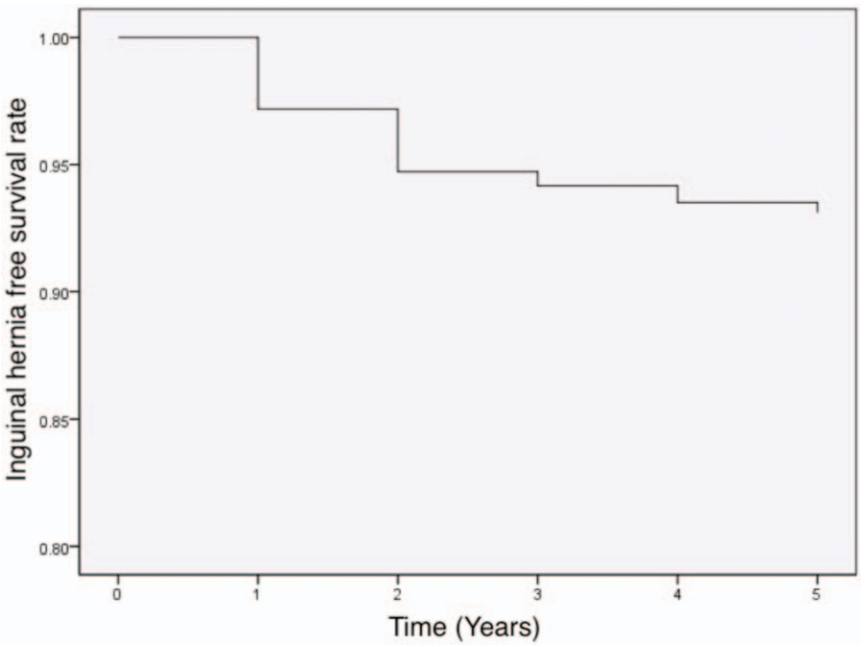

Figure 1. Kaplan–Meier curve of inguinal hernia-free rates after robot-assisted radical prostatectomy.

Table 3

Relationships between preoperative clinical factors/comorbidities and incidence of inguinal hernia (IH) developing after robot-assisted radical prostatectomy (RARP) (N = 427).

Clinical factors		Incidence of IH after RARP		
		No	Yes	P
Age, y	<65	194	14	.9611
	≥65	204	15	
Body mass index, kg/m^2	<24	110	15	.0364
	≥24	175	10	
Smoking history	Absent	318	18	.0236
	Present	80	11	
History of IH repair	Absent	368	27	.8992
	Present	30	2	
History of lower abdominal surgery	Absent	345	25	.9419
	Present	53	4	
Prostate-specific antigen, ng/mL	<10	211	19	.1922
	≥10	187	10	
Comorbidities				
Hypertensive cardovascular disease	Absent	323	21	.2507
	Present	75	8	
Hypertension	Absent	231	14	.3046
	Present	167	15	
Diabetes mellitus	Absent	348	22	.9982
	Present	79	5	

surgery, which dramatically slowed after 3, 4, and >5 years of surgery with a cumulative incidence of 5.71%, 6.21%, and 6.96%, respectively (Fig. 1).

In the univariate analysis of risk factors for IH, data on preoperative factors, comorbidities (Table 3), surgical factors, and pathological factors (Table 4) were collected. BMI, smoking history, and surgeon experience were statistically significantly associated with the incidence of IH after RARP ($P = .036$, .023, and .048, respectively).

In the multivariate analysis shown in Table 5, we listed some factors which were recognized as risk factors for IH. BMI and smoking history were significant factors associated with IH occurrence ($P = .041$ and $P = .048$). However, surgeon experience was not statistically significant for the incidence of IH after RARP.

4. Discussion

Inguinal hernia can lead to inguinal pain and poor quality of life,[11,12] and it was a common disease with prevalence of 1.7%

Table 4

Relationships between surgical and pathological factors and incidence of inguinal hernia (IH) developing after robot-assisted radical prostatectomy (RARP) (N = 427).

Surgical and pathological factors		Incidence of IH after RARP		
		No	Yes	P
Surgeon experience (cases)	Low <175	159	17	.0485
	High ≥175	239	12	
Console time, min	<225	198	14	.5127
	≥225	204	11	
Prostate weight, g	<41	201	11	.1911
	≥41	197	18	
Gleason score	<7	80	8	.3359
	≥7	318	21	
pT stage	≤pT2	253	20	.5589
	≥pT3	145	9	

Table 5

Multivariate analysis with respect to development of inguinal hernia (IH) after robot-assisted radical prostatectomy (RARP) (N = 427).

Variables	Adjusted OR	95% CI	P
History of diabetes mellitus (yes vs no)	1.054	0.729–1.523	.780
History of abdominal surgical history (yes vs no)	1.249	0.152–10.243	.836
Body mass index (<24 vs ≥24 kg/m^2)	3.367	1.054–10.762	.041
History of smoking (yes vs no)	2.868	1.007–8.163	.048
Age (≥65 vs <65 y)	1.124	0.400–3.157	.825
Surgical experience (<175 vs ≥175 cases)	0.564	0.193–1.645	.294

Logistic regression model was used for multivariate analysis.
P value of <.05 was considered to be statistically significant.

for all ages and 4% for those aged over 45 years.[13] It was proved to be a complication in ORP, LRP, and RARP with incidence of around 12.4% to 23.9%,[2,3] 4.9% to 14%,[4–6] and 5.8% to 19.4%, respectively (Table 6). However, none of these studies on post-RARP IH were done by a single surgeon. The possibility of this situation might be due to the low number of cases in each surgeon at one time. Low number of cases for a single surgeon may affect the results because complication due to surgeon's experience and skill play an important role in determining the common complication rate. Some studies reported that it took 150 to 200 cases to cross the learning curve of common complication.[14–16] There were some previous reports on single-surgeon experience at RARP,[15,16] but most of them focus on operation pathology result and common complication such as incisional hernia rather than IH. This is the first study that focuses on post-RARP IH by single surgeon with >400 cases.

Risk factors of previous study about IH after RARP included surgical experience, post-RARP incontinence outcomes, BMI, preoperative IPSS score, presence of patent processus vaginalis (PPV), age, history of previous abdominal surgery, and higher tumor stage (Table 6). Our study showed that low BMI and smoking history are associated with IH incidence after RARP, and age, history of previous abdominal surgery, tumor stage, and learning curve were not significant. The learning curve reported by other studies may affect IH occurrence after RARP.[2] However, in our study, it showed statistical significance in the univariate analysis initially, but no significance in the multivariate analysis. Giovanni reported that an experience of 175 cases is the point in the learning curve,[15] which showed that post-RARP complication rate had significantly decreased after 175 procedures. With a single surgeon doing RARP, we can clearly found the effect of the learning curve and need not drop the first few cases[17] or set a low curve point (n = 40).[2] Low BMI and smoking history were considered risk factors for IH.[18,19] However, one study showed that high BMI was a risk factor for IH.[17] Our study showed that low BMI was statistically significantly related with post-RARP IH, and this was confirmed by 2 other studies.[3,20] Low BMI means less abdominal wall and fat, which may play a role in preventing IH protrusion from the internal orifice or Hesselbach's triangle. Smoking may induce IH by changing collagen composition and causing chronic cough which may increase the intra-abdominal pressure. Various factors induced post-RARP IH (Table 6); however, they may also increase the IH incidence at ORP[21–23] in general situation. Our study collected >10 years cases and observed that about 80% of post-RARP IH case happened within the first 2 years. This was also observed by different studies (Table 6), but was not

Table 6

Current studies of inguinal hernia after robot-assisted radical prostatectomy.

Author	Research period	Duration	Cases	Single or multiple surgeons	IH diagnosed way	Statistically significant factors	Frist 2 y IH rate, %	General IH rate, %	Indirect type IH, %	Right-side IH, %
Yuta et al (2017)	2011.01–2015.08	4Y07M	308	Multiple surgeons	CT	Surgical experience <40 cases, incontinence outcomes at 3 mo	14	15.40	90	43.0%
Tsuyoshi et al (2017)	2012.02–2015.01	2Y11M	284	Multiple surgeons	Clinical Dx	Preoperative IPSS question 5 score >2, preoperative IPSS question 6 score >2, the existence of PPV, BMI ≥ 23	About 13	14.70	95.2	83.3
Masaki et al (2017)	2011.09–2013.10	2Y01M	161	Multiple surgeons	Clinical Dx	The existence of PPV	About 18	19.40	Not mention	64.2
Dong et al (2012)	2007.01–2011.11	4Y10M	205	Multiple surgeons	Clinical Dx	Age, low BMI, history of previous abdominal surgery, the existence of PPV	Not mention	8.30	95	60
Johan et al (2010)	2002.01–2006.12	4Y11M	864	Multiple surgeons	Questionnaire	Age, low BMI, history of previous abdominal surgery, higher tumor stage	About 4.5	5.80	Not mention	Not mention

BMI = body mass index, CT = computed tomography, Dx = diagnose, IH = inguinal hernia, IPSS = International Prostate Symptom Score, M = months, PPV = patent processus vaginalis, Y = years.

similar to ORP in which IH still occurred gradually even after long following time.[22,23] With this special characteristic, RARP might be seen as a risk factor of IH. This concept help clinician in organizing treatment programs after RARP clearly, such as educating patient to avoid heavy load within the first 2 years after the operation.

After our long-term follow-up research and comparison with other articles (Table 6), we found that the timing of IH after RARP was in 2 years, and $>90\%$ were indirect hernia. This did not seem to occur in ORP as IH happened gradually and keep for a long time. This implied that RARP itself may directly induce IH occurrence. Although some risk factors were described previously, they were unspecific and only increased the rate of IH rather than induced its occurrence. The possible mechanism for post-RARP IH can be categorized into 3: first, surgeons performing RARP can make wider surgical field and exposure because of the magnified vision and extended mobility. This may dissect and damage the transversalis fascia, which composed the internal ring and protected the protruding hernia. Interestingly, if the transversalis fascia is intact even by ORP, the rate of IH occurrence was much lower at 0% to 1.8%.[2,24,25] Second, during RARP, the abdominal pressure should be increased to keep the operational view and to decrease the oozing of tissue. Meanwhile, the operator needs to suction the smoke from the electrocoagulation system and bleeding from the incision, which will decrease the abdominal pressure. This repeated change in intra-abdominal pressure is associated with reduced muscle tone or other connective tissue abnormalities around the internal ring.[17,26] Third, after prostatectomy and urethrovesical anastomosis, the peritoneum and vas deferens were stretched, thereby shifting the position of rectovesical excavation and the internal ring, which may further induce IH.[27] The presence of a PPV was considered a risk factor for IH, which also widens the internal ring.[17,27,20] These reasons may influence directly the internal ring and induce IH occurrence; however, the symptoms might be delayed until the hernia protrudes through the internal ring.

Our study showed significant IH laterality after RARP with 65.5% of IH occurrence at right-side post-RARP IH, which corresponded with general population, showing that IH occurs in the right side in two-thirds of patients.[28] Right-side dominance of IH after RARP was also reported in some articles (Table 6). This phenomenon may due to the asymmetric anatomy because the sigmoid colon is at the left side. The sigmoid colon may play a role in preventing hernia by adhering to the dissected pelvic floor and left internal ring after RARP.[17,29]

Some methods were developed to decrease the rate of post-RARP IH. Lee et al[30,31] used mesh repair a plugging hemostatic agent for PPV. Masaki et al[27] develop a procedure to reduce tension from the peritoneum to the internal inguinal ring. Both techniques were used to prevent IH during RARP. However, these methods were not generally accepted and standardized and may increase the operation time. Before further investigation is done, postoperative care and prevention must be emphasized within 2 years after operation such as quitting smoking, avoiding a persistent cough, maintaining a healthy body weight, avoiding straining during bowel movements or urination, and so on.

This study had several limitations. First, our study was a retrospective study rather than a prospective, randomized controlled study. Second, it is unknown if more conservative treatment within 2 years can reduce the rate of IH rather than those prevention technologies. Third, we confirmed IH rates by herniorrhaphy, which may miss some undetectable hernia. Fourth, although our record spans for >10 years, we did not

record PPV and post-RARP incontinence rate, which was seen as a risk factor for IH (Table 6). Fifth, more studies must be done in the future to make better conclusion.

5. Conclusion

This long-period study showed the high occurrence rates of IH after RARP within first the 2 years. By single operator's experience with >400 patients, we can rule out the learning curve's effect and focus on other risk factors. Low BMI and smoking history increased the possibility of IH occurrence after RARP. The idea following time of post-RARP IH was 2 years for each clinician and patient.

Author contributions

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