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. 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 radical prostatectomy (ORP) and laparoscopic radical prostatectomy (LRP) was 12.4% to 23.9% and 4.9% to 14%, 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. In recent years, some studies started to discuss the risk factor of post-RARP IH. However, all articles are multisurgeon, 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. 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 χ² test to determine the incidence
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. 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 < 365 d was 12 (41.4%), < 730 d was 10 (34.5%), < 1095 d was 2 (6.9%), < 1460 d was 2 (6.9%), and ≥ 1460 d was 3 (10.3%).

### Table 1

| Variables                | Median value (IQR) or N (%) |
|--------------------------|----------------------------|
| Age, y                   | 65 (40–85)                 |
| Preop-PSA, ng/mL         | 10.2 (0.1–298)             |
| Body mass index, kg/m²   | 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.
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,

| 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/m² | | | |
| <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 | | |
| ≥10 | 187 | 10 | |
| Comorbidities | | | |
| Hypertensive cardiovascular disease | | | |
| Absent | 323 | 21 | .2507 |
| Present | 75 | 8 | |
| Hypertension | | | |
| Absent | 231 | 14 | .3046 |
| Present | 167 | 15 | |
| Diabetes mellitus | | | |
| Absent | 348 | 22 | .9882 |
| Present | 79 | 5 | |

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

| Table 5 | 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/m²) | 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, some 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.\[22\] 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 = 100) in general situation.\[2\] 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.\[23\] Our study showed that low BMI was statistically significantly related with post-RARP IH, and this was confirmed by 2 other studies.\[5,20\] Low BMI means less abdominal wall and fat, which may play a role in preventing IH protrusion from the internal orifice of 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
| Author          | Research period       | Duration | Cases | Single or multiple surgeons | IH diagnosed way | Statistically significant factors | Frst 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 PSS 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          | Not mention       | 19.40             | 6.42              |
| 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 | About 45          | 8.30              | 96                | 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 | 5.80              | Not mention       | Not mention       | Not mention       |

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

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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 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.

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