Original Article

Robot-assisted radical prostatectomy using the novel hinotori™ surgical robot system: initial experience and operation learning curve at a single institution

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Background: The hinotori™ surgical robot system (HSRS) is the first made-in-Japan robotic system used for radical prostatectomy. Here, we report initial results and describe our learning curve (skill development) implementing robot-assisted radical prostatectomy using HSRS (h-RARP).

Methods: Between November 2021 and December 2022, 97 patients who underwent h-RARP at our institution were enrolled in this study. We retrospectively evaluated the surgical outcomes of the initial cases using h-RARP, comparing those of RARP using da Vinci surgical robot system (d-RARP) in our institution. Furthermore, the learning curves of two surgeons with the highest number of h-RARP were analyzed. Patients treated by each surgeon were categorized into two groups: 1–15 cases (earlier group) and >15 cases (later group). Preoperative patient characteristics, operation parameters, and complication rates were compared between the two groups.

Results: In terms of surgical outcome, h-RARP was comparable to d-RARP. The procedures performed by the HSRS were successfully completed in all cases. There was no complication of grade 3 or higher. Comparing the two surgeons, surgeon 1, who had performed 40 d-RARP procedures, had time using robot system of the later group that was significantly shorter than that of the earlier group. However, for surgeon 2 with more than 100 d-RARP procedures, there was no statistically significant difference in time using robot system between groups. Other parameters showed no difference between earlier and later groups for the two surgeons.

Conclusions: Our results show that surgical outcomes of h-RARP are comparable to those of d-RARP during the initial experience of clinical application. In addition, the surgeons' learning curves for the total RARP experience suggest that the experience of d-RARP can carry over to performance using the novel HSRS.

Keywords: hinotori™ surgical robot system (HSRS); robot-assisted radical prostatectomy (RARP); learning curve

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Introduction

Prostate cancer (PCa) is one of the most prevalent malignancies in men worldwide, with the second highest incidence and the fifth highest mortality in 2020 (1). Radical prostatectomy is a gold standard treatment for localized PCa (2). Previously, this surgery was performed using a retropubic open approach (3). With the introduction of optical equipment into the surgery, laparoscopic radical prostatectomy has been developed (4). Since the da Vinci surgical robot system (da Vinci; Intuitive, Sunnyvale, CA, USA) was approved in the US in 1999, its ability to perform delicate movements with a magnified field of view has resulted in this surgical system being rapidly implemented for radical prostatectomy. At present, robot-assisted radical prostatectomy (RARP) with da Vinci (d-RARP) is being performed worldwide as the standard minimum invasive surgery (5). Under these circumstances, the hinotori™ surgical robot system (HSRS; Medicaroid Corp, Kobe, Japan) was approved in Japan in 2020. Currently, HSRS is used not only in urology, but also in the gynecology and gastrointestinal surgery fields. However, this system is still in early stages of introduction, and the further accumulation of evidence of this system is required. At our institution, which has used d-RARP, RARP using HSRS (h-RARP) was first used in 2021. Since then, we have performed most radical prostatectomies using HSRS. In this study, we analyzed the results of our initial experience using h-RARP, including the learning curve of surgeons in performing h-RARP. We present this article in accordance with the STROBE reporting checklist (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1025/rc).

Highlight box

Key findings

- The hinotori™ surgical robot system (HSRS), the first made-in-Japan robotic system, can be introduced safely in the treatment of robot-assisted radical prostatectomy (RARP).

What is known and what is new?

- In our initial experience, the surgical outcomes of RARP using HSRS (h-RARP) were comparable to those of RARP using da Vinci surgical robot system (d-RARP).
- The surgeon learning curve observed in h-RARP was influenced by the total RARP cases performed, including d-RARP.
- The experience of d-RARP can carry over to the novel h-RARP.

What is the implication, and what should change now?

- Currently, the development of several surgical robot systems is progressing all over the world. The HSRS can be safely introduced to teams with experience in the da Vinci surgical robot system.

Methods

Patients

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of Dokkyo Medical University Saitama Medical Center (No. 23023) and informed consent was obtained from all individual participants. We retrospectively evaluated consecutive 97 patients from the initial case who underwent h-RARP at our institution between November 2021 and December 2022. RARP using da Vinci Xi via transperitoneal approach has been performed since 2017 for 269 patients. Twenty-five patients underwent d-RARP after the initiation of h-RARP according to availability of robotic system. Tumor staging was based on the American Joint Committee on Cancer (8th edition) Cancer Staging Manual (6). Pathological findings were evaluated based on the International Society of Urologic Pathology 2005 Guidelines (7). The RARP-related complications within 90 days after surgery were evaluated according to the Clavien-Dindo classification (8).

HSRS (Figure 1)

HSRS consists of a surgeon cockpit, an operation unit, and a monitor cart. The positions of the viewer, hand controller, arm rest, and foot unit in the surgeon cockpit are similar to those of da Vinci. Electric devices including monopolar and bipolar are operated using the right foot. The forceps switching pedal, hand controller, and camera clutch pedal are located on the left foot. The patient is positioned supine with the head down at 25° and HSRS is parallel docked.

Surgical procedure

h-RARP was performed using the same technique of d-RARP of a six ports approach (*Figure 2*). Five surgeons with experience in d-RARP of at least 40 cases performed h-RARP. The choice of pelvic lymphadenectomy was at the discretion of the surgeon.

Perioperative outcomes

All data of 97 patients underwent h-RARP were compared with 246 patients underwent d-RARP excluding 23 patients

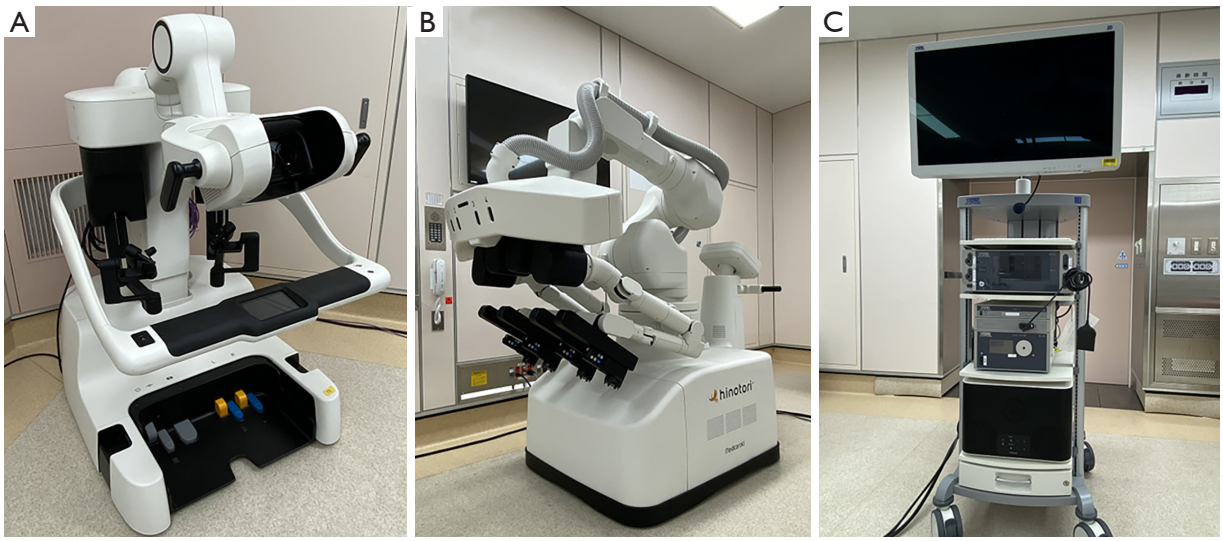

Figure 1 The hinotori™ surgical robot system. (A) Surgeon cockpit. (B) Operation unit. (C) Monitor cart.

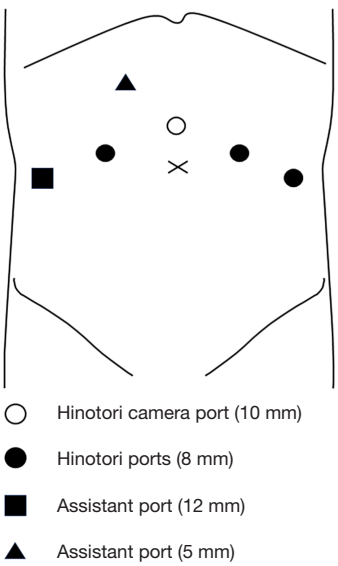

Figure 2 Placement of ports.

with missing data, in terms of surgical and pathological outcomes.

Surgeon performance

Of the five surgeons, the learning curves of the two surgeons (surgeons 1 and 2) with the highest number of surgeries were analyzed. Patients operated by each surgeon were categorized into two groups: 1–15 cases (earlier group) and >15 cases (later group). Preoperative patient characteristics, operation parameters, and complication rates were compared between the two groups.

Statistical analysis

Quantitative variables were expressed as medians with interquartile ranges (IQRs) and analyzed using Wilcoxon rank sum test. Categorical variables were compared using Fisher's exact test or Chi-squared test. All statistical analysis were performed using JMP® software (version 12.2.0; SAS Institute Inc., Cary, NC, USA) and EzR (R commander version 1.54) with $P<0.05$ indicating statistical significance.

Results

Patient characteristics

Baseline characteristics are shown in *Table 1*. In terms of clinical T stage (cT), biopsy Gleason grade group and National Comprehensive Cancer Network (NCCN) risk classification, significance differences were found between h-RARP and d-RARP ($P=0.02$, $P<0.001$ and $P=0.03$, respectively). However, no significant differences were noted in any other examined baseline characteristics.

Surgical outcomes

The surgical and pathological outcomes are summarized in *Table 2*. The time using the robotic system in the h-RARP

Table 1 Patient characteristics

Characteristics	h-RARP (n=97)	d-RARP (n=246)	P value
Age (years), median [IQR]	69 [63.5–73.0]	69 [65.0–72.0]	0.76
BMI (kg/m^2), median [IQR]	24.1 [22.3–27.0]	23.7 [21.9–26.0]	0.13
ASA physical status, n (%)			0.61
1	19 (19.6)	53 (21.5)	
2	74 (76.3)	176 (71.5)	
3	4 (4.1)	17 (6.9)	
Initial PSA (ng/dL), median [IQR]	7.2 [5.4–10.8]	7.4 [5.4–11.3]	0.75
Prostate volume (mL), median [IQR]	32.9 [26.0–40.0]	31.9 [24.8–40.0]	0.77
Clinical T stage, n (%)			0.02
T1	28 (28.9)	42 (17.1)	
T2	59 (60.8)	160 (65.0)	
T3	10 (10.3)	44 (17.9)	
Biopsy Gleason grade group, n (%)			<0.001
1	5 (5.2)	46 (18.7)	
2	16 (16.5)	68 (27.6)	
3	32 (33.0)	52 (21.1)	
4	35 (36.1)	67 (27.2)	
5	9 (9.3)	13 (5.3)	
NCCN risk classification, n (%)			0.03
Low	3 (3.1)	26 (10.6)	
Intermediate	47 (48.5)	115 (46.7)	
High	46 (47.4)	94 (38.2)	
Very high	1 (1.0)	11 (4.5)	
Follow-up (months), median [IQR]	8.0 [5.0–12.0]	29.5 [17.0–47.0]	<0.001

h-RARP, robot-assisted radical prostatectomy using hinotori™ surgical robot system; d-RARP, robot-assisted radical prostatectomy using da Vinci surgical robot system; IQR, interquartile range; BMI, body mass index; ASA, American Society of Anesthesiologists; PSA, prostate-specific antigen; NCCN, National Comprehensive Cancer Network.

group were longer than those in the d-RARP group (P<0.001), while no significance difference were found in the estimated blood loss (EBL) and nerve-sparing rate (P=0.11 and P=0.12, respectively). Pathological findings showed significant differences in T stage and Gleason grade group (P=0.008 and P=0.001, respectively), however, there were no significant difference in positive surgical margin status (P=0.69). No h-RARP-related perioperative complications were identified according to the Clavien-Dindo classification.

Learning curve

A comparison of patient characteristics and surgical outcomes between the two surgeons with the highest numbers of h-RARP at our institution is presented in *Table 3*. The number of d-RARP performed by surgeon 1 and surgeon 2 was 40 and >100, respectively. For surgeon 1, the later group had a significantly shorter cockpit time than the earlier group; however, there were no statistically significant differences between the earlier group and later

Table 2 Surgical and pathological outcomes

Outcomes	h-RARP (n=97)	d-RARP (n=246)	P value
Time using robot system (min), median [IQR]	173 [141–207]	144 [112–190]	<0.001
Estimated blood loss (mL), median [IQR]	20 [10–50]	25 [10–90]	0.11
Nerve-spare, n (%)			0.12
Unilateral	23 (23.7)	35 (14.2)	
Bilateral	2 (2.1)	6 (2.4)	
Not performed	72 (74.2)	205 (83.3)	
Perioperative complications (Clavien-Dindo calcification grade ≥3), n (%)	0 (0.0)	4 (1.6)	0.58
Pathological T stage, n (%)			0.008
T0	3 (3.1)	1 (0.4)	
T2	58 (59.8)	183 (74.4)	
T3	36 (37.1)	60 (24.4)	
T4	0 (0.0)	2 (0.8)	
Pathological Gleason score, n (%)			0.001
No cancer	3 (3.1)	1 (0.4)	
1	1 (1.0)	13 (5.3)	
2	17 (17.5)	90 (36.6)	
3	37 (38.1)	69 (28.0)	
4	19 (19.6)	36 (14.6)	
5	20 (20.6)	37 (15.0)	
Surgical margin status, n (%)			0.69
Negative	62 (63.9)	151 (61.4)	
Positive			
With pT2	18 (31.0)	57 (31.1)	
With pT3	17 (47.2)	36 (60.0)	

h-RARP, robot-assisted radical prostatectomy using hinotori™ surgical robot system; d-RARP, robot-assisted radical prostatectomy using da Vinci surgical robot system; IQR, interquartile range.

group in terms of patient characteristics and other surgical outcomes. For surgeon 2, there were no statistically significant differences between the earlier group and later group in any patient characteristics and surgical outcomes.

Discussion

The current study reports initial results of h-RARP at an institution with experience using d-RARP. HSRS can be introduced safely, based on the experience of using da Vinci, and is useful as a novel surgical robot system from Japan.

Surgical outcomes of h-RARP were comparable to those of d-RARP, except for time using robot system, although there were some differences in baseline characteristics between h-RARP and d-RARP patients. Time using robot system is expected to decrease as surgeons and assistants become more proficient in h-RARP. Positive surgical margin status which is an important pathological factor, of h-RARP showed no significant difference from that of d-RARP. Pelvic lymphadenectomy has not routinely been performed because survival benefit was not proved (9). All h-RARP were completed without open conversion, and

Table 3 Comparison of patient characteristics and surgical outcomes between two surgeons performing robot-assisted radical prostatectomy using the hinotori™ surgical robot system

Variables	Overall	Earlier group	Later group	P value
Surgeon 1				
Age (years), median [IQR]	67.5 [60.0–73.3]	67 [60–73]	68 [61–74]	0.68
BMI (kg/m^2), median [IQR]	24.4 [22.7–26.3]	25.5 [22.7–27.6]	24.0 [22.6–24.9]	0.17
Initial PSA (ng/mL), median [IQR]	7.5 [5.3–11.2]	7.24 [5.44–10.3]	7.70 [4.71–15.0]	0.83
Prostate volume (mL), median [IQR]	30.1 [24.4–38.4]	29.2 [22.0–37.6]	30.9 [24.7–39.7]	0.67
Clinical T stage (T1/T2/T3), n	11/15/4	6/8/1	5/7/3	0.77
Biopsy Gleason grade group (1/2/3/4/5), n	0/3/12/13/2	0/2/6/6/1	0/1/6/7/1	>0.99
Cockpit time (min), median [IQR]	173 [160–200]	192 [170–210]	162 [150–190]	0.02
Nerve-spare (unilateral/bilateral/not performed), n	13/1/16	6/0/9	7/1/7	0.72
Estimated blood loss (mL), median [IQR]	20 [10–35]	20 [9–30]	20 [10–50]	0.35
Positive surgical margin status, n (%)	9 (30.0)	5 (33.3)	4 (26.7)	>0.99
Any grade complications, n (%)	7 (23.3)	4 (26.7)	3 (20.0)	>0.99
Surgeon 2				
Age (years), median [IQR]	68 [65–73]	71 [66–74]	67 [60.5–69.5]	0.11
BMI (kg/m^2), median [IQR]	23.0 [21.3–25.0]	22.9 [21.0–25.0]	23.0 [21.5–25.6]	0.86
Initial PSA (ng/mL), median [IQR]	7.18 [5.28–10.5]	5.65 [5.03–7.69]	8.99 [6.31–12.6]	0.25
Prostate volume (mL), median [IQR]	33.9 [27.5–47.9]	30.0 [27.5–51.5]	37.0 [27.0–44.7]	0.96
Clinical T stage (T1/T2/T3), n	8/18/1	3/11/1	5/7/0	0.40
Biopsy Gleason grade group (1/2/3/4/5), n	3/8/7/7/2	1/4/4/4/2	2/4/3/3/0	0.83
Cockpit time (min), median [IQR]	120 [104–126]	120 [104–128]	121 [108–126]	0.92
Nerve-spare (unilateral/bilateral/not performed), n	1/0/26	0/0/15	1/0/11	0.44
Estimated blood loss (mL), median [IQR]	10 [5–20]	10 [5–20]	12.5 [5–41]	0.58
Positive surgical margin status, n (%)	11 (40.7)	4 (26.7)	7 (58.3)	0.13
Any grade complications, n (%)	6 (22.2)	4 (26.7)	2 (16.7)	0.66

IQR, interquartile range; BMI, body mass index; PSA, prostate-specific antigen.

no complications occurred that were grade 3 or higher. Therefore, we considered h-RARP as safe. Using the experience of d-RARP, a smooth transition to h-RARP was possible without changing surgical procedures.

HSRS is a master-slave type robot with four articulated forceps. In addition, the three-dimensional expanded field of view provides an environment in which delicate manipulation is possible. As with da Vinci, HSRS allows the surgeon to perform intuitive surgical operations as desired. The major difference from da Vinci Xi is the clutch switching using foot pedal, however, this does not affect surgical performance. Since the concept of HSRS is similar to that of da Vinci, the surgeon's experience with HSRS is similar to that of da Vinci.

HSRS differs from da Vinci in the docking-free design, in which the robot arms do not need to connect to the ports directly (*Figures 3*,*4*). The set of pivoting point is needed during the docking. This design gives assistants a spacious working area.

When using multiple types of robots at an institution, the learning curve required for each robot becomes an issue. In this study, an accumulation effect of the learning curves was observed when the robot was changed from da Vinci to HSRS. Surgeon 1, with only 40 d-RARP experiences,

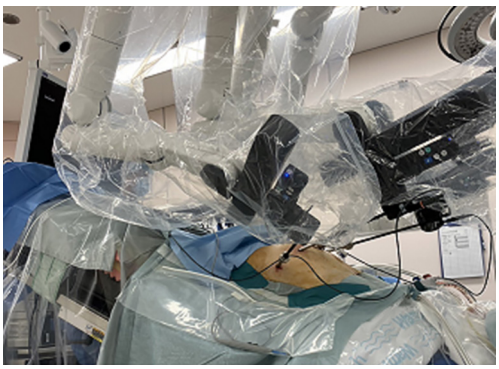

Figure 3 Docking-free design of hinotori™ surgical robot system.

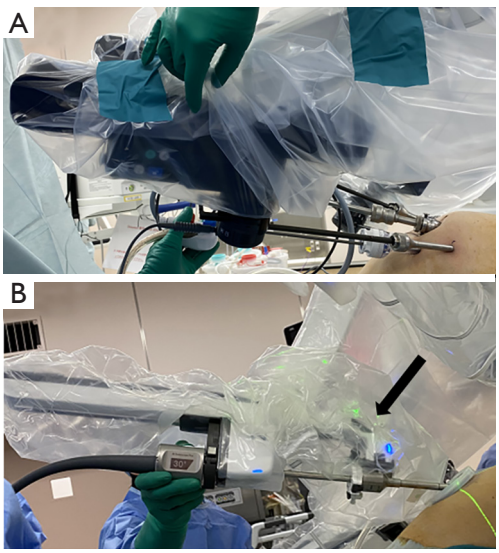

Figure 4 The arms of HSRS and ports are undocked, whereas the arms of da Vinci and ports are docked (arrowhead). (A) HSRS. (B) da Vinci. HSRS, hinotori™ surgical robot system; da Vinci, da Vinci surgical robot system.

reduced the cockpit time during initial 15 h-RARP cases. In contrast, a learning curve for h-RARP was not observed for surgeon 2, who experienced more than 100 d-RARP cases. Several studies have shown that the operative time of the initial 40–50 cases was significantly longer than the subsequent cases (10-12). Overall, a learning curve of 50–100 cases may be needed for the surgeon's operative time to reach a plateau.

Our results were obtained using surgeons with experience in RARP. As HSRS becomes more prevalent in Japan, the number of surgeons who begin their robot-assisted surgery experience using HSRS will increase. Trainee surgeons' learning curves using various metrics including proficiency score (13,14). Furthermore, in the era of multiple robot systems, surgeon proficiency with each robot system and surgeon compatibility between robot systems need to be investigated. However, our results suggest good surgeon compatibility between HSRS and da Vinci.

There are a few limitations to the present study. First, the study was a retrospective analysis of data collected from patients who were treated with h-RARP at one institution. In addition, the short follow-up period may decrease the accuracy of the data. Second, the assessment of learning curve was based on the data from only two surgeons; thus, analyzing with a larger number of data could yield different results. However, our study shows that HSRS can be safely introduced in institutions currently conducting RARP.

Conclusions

HSRS was developed in Japan and can be implemented safely in clinical practices already conducting RARP. The experience of da Vinci carries over to the surgical technique of HSRS, and the oncological outcomes of h-RARP are similar to that of d-RARP.

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Footnote

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Conflicts of Interest: All authors have completed the ICMJE

uniform disclosure form (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1025/coif). The series "Current Status of Robotic Surgery for Genitourinary Diseases in Japan" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of Dokkyo Medical University Saitama Medical Center (No. 23023) and informed consent was obtained from all individual participants.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin 2021;71:209-49.
2. Mottet N, Bellmunt J, Bolla M, et al. EAU-ESTRO-SIOG Guidelines on Prostate Cancer. Part 1: Screening, Diagnosis, and Local Treatment with Curative Intent. Eur Urol 2017;71:618-29.
3. Walsh PC, Partin AW, Epstein JI. Cancer control and quality of life following anatomical radical retropubic prostatectomy: results at 10 years. J Urol 1994;152:1831-6.
4. Krongrad A. Laparoscopic radical prostatectomy. Curr Urol Rep 2000;1:36-40.
5. Leal Ghezzi T, Campos Corleta O. 30 Years of Robotic Surgery. World J Surg 2016;40:2550-7.
6. Buyyounouski MK, Choyke PL, McKenney JK, et al. Prostate cancer - major changes in the American Joint Committee on Cancer eighth edition cancer staging manual. CA Cancer J Clin 2017;67:245-53.
7. Epstein JI, Allsbrook WC Jr, Amin MB, et al. The 2005 International Society of Urological Pathology (ISUP) Consensus Conference on Gleason Grading of Prostatic Carcinoma. Am J Surg Pathol 2005;29:1228-42.
8. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009;250:187-96.
9. García-Perdomo HA, Correa-Ochoa JJ, Contreras-García R, et al. Effectiveness of extended pelvic lymphadenectomy in the survival of prostate cancer: a systematic review and meta-analysis. Cent European J Urol 2018;71:262-9.
10. Gumus E, Boylu U, Turan T, et al. The learning curve of robot-assisted radical prostatectomy. J Endourol 2011;25:1633-7.
11. Zorn KC, Orvieto MA, Gong EM, et al. Robotic radical prostatectomy learning curve of a fellowship-trained laparoscopic surgeon. J Endourol 2007;21:441-7.
12. Hashimoto T, Yoshioka K, Gondo T, et al. Learning curve and perioperative outcomes of robot-assisted radical prostatectomy in 200 initial Japanese cases by a single surgeon. J Endourol 2013;27:1218-23.
13. Anceschi U, Galfano A, Luciani L, et al. Analysis of predictors of early trifecta achievement after robot-assisted radical prostatectomy for trainers and expert surgeons: the learning curve never ends. Minerva Urol Nephrol 2022;74:133-6.
14. Anceschi U, Morelli M, Flammia RS, et al. Predictors of trainees' proficiency during the learning curve of robot-assisted radical prostatectomy at high- -volume institutions: results from a multicentric series. Cent European J Urol 2023;76:38-43.

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