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[Review]

Comprehensive approach for post-prostatectomy incontinence in the era of robot-assisted radical prostatectomy

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Abstract

Robot-assisted radical prostatectomy (RARP) has enabled steady and stable surgical procedures due to both meticulous maneuvers and magnified, clear, 3-dimensional vision. Therefore, better surgical outcomes have been expected with RARP than with other surgical modalities. However, even in the RARP era, post-prostatectomy incontinence has a relatively high incidence as a bothersome complication. To overcome post-prostatectomy incontinence, it goes without saying that meticulous surgical procedures and creative surgical procedures, i.e., "Preservation", "Reconstruction", and "Reinforcement" of the anatomical structures of the pelvis, are most important. In addition, medication and appropriate pad usage might sometimes be helpful for patients with post-prostatectomy incontinence. However, patients who have 1) BMI $\geq$ 26 kg/m^2, 2) prostate volume $\geq$ 70 mL, 3) eGFR $\leq$ 60 mL/min, or a 4) Charlson comorbidity index $\geq$ 2 have a tendency to develop post-prostatectomy incontinence despite undergoing the same surgical procedures. It is important for patients who have a high risk for post-prostatectomy incontinence to be given information about delayed recovery of post-prostatectomy incontinence. Thus, not only the surgical procedures, but also a comprehensive approach, as mentioned above, are important for post-prostatectomy incontinence.

Key words : robot, prostate cancer, urinary incontinence, lower urinary tract, radical prostatectomy

Introduction

Radical prostatectomy for localized prostate cancer started with the open procedure, progressed to the laparoscopic procedure, and then evolved to the robot-assisted procedure with changing times. Because it is difficult to control bleeding with open radical prostatectomy (ORP), the thrust of ORP is safely removing the prostate by hemostasis of the dorsal vein complex. On the other hand, because laparoscopic radical prostatectomy (LRP) provides magnified, clear vision, it is easier to remove the prostate with it than with ORP. However, after removing the prostate, it is difficult to perform the vesicourethral anastomosis with two-dimensional vision, except for some skilled surgeons. Hence, although the importance of trifecta and pentafecta were recognized by our urologists, it was hard for them to accomplish the trifecta and pentafecta. In Japan, robot-assisted radical prostatectomy (RARP) has been allowed by the national medical insurance system since 2012. After the introduction of RARP, the number of patients who underwent RARP increased steadily in Japan. Because RARP enabled steady and stable surgical procedures due to both meticulous maneuvers and magnified, clear, 3-dimensional vision, better surgical outcomes have been expected with RARP than with both ORP and LRP.

Post-prostatectomy incontinence has a relative-

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ly high incidence as a bothersome complication after radical prostatectomy. Even in the RARP era, because the continence rate is only 17% just after urethral catheter withdrawal in high-volume institutions[1], various trials for early acquisition of urinary continence have been conducted[2]. As mentioned above, because a steady and stable surgical procedure has been enabled under RARP, creative surgical procedures, medication, and physical therapy have become more important for early acquisition of urinary continence in the RARP era. In addition, prediction of which patients are more likely to have prolonged urinary incontinence after surgery and countermeasures for such patients are now becoming more important. In the present review, we provide a critical summary of current knowledge on this outcome in the literature and discuss the pathophysiology of post-prostatectomy incontinence and the various countermeasures for early acquisition of urinary incontinence.

1. Surgical modalities for early acquisition of urinary continence

Due to the clear view and meticulous maneuvers possible with RARP, we presumed that surgeons who have once performed RARP are not willing to perform ORP and LRP. However, is RARP the surgical approach that offers the earliest acquisition of urinary continence among the three surgical modalities, i.e., RARP, LRP, and ORP ? While RARP was reported to be associated with the earliest acquisition of urinary continence among the three surgical modalities[2,3], a multi-institutional study in Sweden, which was a prospective non-randomized deign involving 2,625 patients, demonstrated that there was no significant difference in the continence rate 12 months after surgery between RARP and ORP[4]. Further, a randomized, controlled trial recently demonstrated similar urinary function evaluated by patient-reported outcomes at 6 and 12 weeks after surgery with RARP and ORP[5]. Ferronha *et al.* reported that there were no significant differences in the postoperative continence rate among RARP, LRP, and ORP in their systematic review[6]. However, because individual Japanese physicians could not perform as many cases of RARP as physicians in high-volume Western centers, these data about continence status with each surgical modality might not reflect the situation in Japan.

Regarding the achievement of mastery of the surgical procedures, while LRP needs no less than 40-100 cases, RARP needs about 12-20 cases if the physicians have performed ORP before performing RARP[7]. With respect to the vesicourethral anastomotic technique for acquisition of urinary continence, Good *et al.* reported that a shorter period is needed to master the vesicourethral anastomosis with RARP than with LRP[8]. A report from Japan demonstrated that the pad-free rate 12 months after RARP was 88% following procedures performed by surgeons with previous experience with ORP, and 75% following procedures performed by surgeons with no previous experience with ORP[9]. In addition, even though LRP had not been performed before introduction of RARP in that institution, perioperative outcomes, including the continence rate, were good from the introduction of RARP[9]. As just described, RARP might be easier to master within a shorter period than other surgical modalities even by surgeons with no experience with LRP and/or ORP. Therefore, the number of cases in which RARP was performed has increased in Japan, instead of there being an increase in LRP cases, as in the United States of America in the past.

2. "Preservation", "Reconstruction", and "Reinforcement" of the anatomical structures of the pelvis

We have previously reported the effects of surgical techniques for "preservation", "reconstruction", and "reinforcement" of anatomical structures of the pelvis on the early acquisition of urinary continence after RARP[10,11]. Because all these surgical procedures are important for early acquisition of urinary continence after radical prostatectomy, we could not determine which techniques are most important at the present.

However, our previous study demonstrated that "preservation" of membranous urethral length was the most important factor, at least in the early postoperative period after RARP (Figure 1)[12]. Based on our study, we take minimal bites of the needle at the anterior aspect of the Ω-shaped membranous urethra during RARP to leave it long postoperatively (Figure 2). We also demonstrated that the postoperative membranous urethra was significantly retained in the nerve-sparing group compared with the non-nerve-sparing group[12]. In addition, the nerve-sparing procedure in RARP has the possibility to improve not only erectile function, but also lead to early improvement of lower urinary tract symptoms (LUTS), due to both the increase of maximum voided volume and the decrease of nocturia[13]. There-

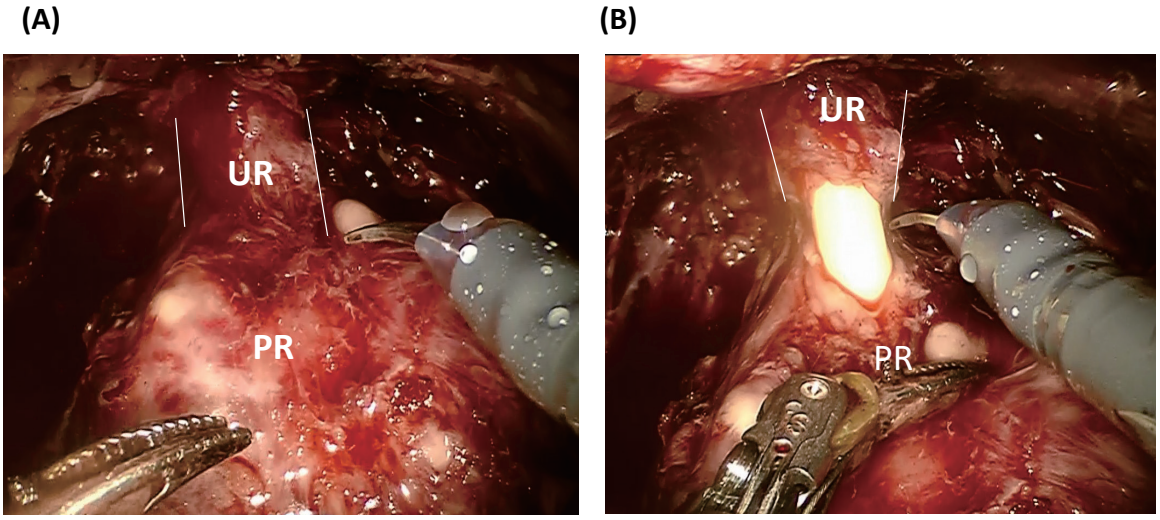

Fig. 1. Preservation of membranous urethral length during robot-assisted radical prostatectomy
(A) Representative photograph before dividing between urethra and prostate
Before dividing urethra and prostate, it is important to clearly show the association between urethra and prostate to preserve the postoperative membranous urethral length.
(B) Representative photograph during the dividing between urethra and prostate
Urethra was cut as nearly as possible at the prostatic apex.
UR ; urethra, PR ; prostate

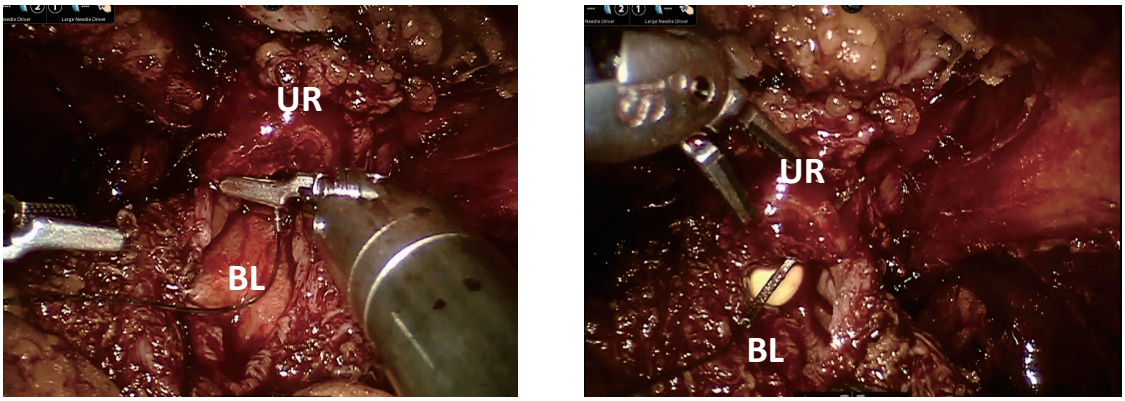

Fig. 2. Artifice of preserving the membranous urethral length
We take minimal bites of the needle at the anterior aspect of the Ω-shaped membranous urethra during vesico-urethral anastomosis at robot-assisted radical prostatectomy to leave it long postoperatively.
UR ; urethra, BL ; bladder

fore "preservation" of erectile nerves is involved in the early acquisition of urinary continence and in the early improvement of LUTS after radical prostatectomy.

However, although "preservation" of erectile nerves was significantly associated with this early acquisition of urinary continence 6 months after radical prostatectomy in meta-analyses[14], the procedure is not associated with urinary continence both 12 months and 24 months after RARP. Thus, this meta-analysis concluded that, because evidence for acquisition of urinary continence was not sufficient with the nerve-sparing procedure, whether the nerve-sparing procedure is performed should be decided based on the degree of spread of the cancer both on imaging findings and the results of prostatic needle biopsy, especially in patients with preoperative erectile dysfunction[14].

Regarding the "reconstruction" of pelvic organs, the Rocco technique for posterior reconstruction of Denonvilliers' fascia[15] is performed in many institutions, because it is easy to perform and it is completed in a short amount of time (Figure 3). In a systematic review of the effect of posterior musculofascial reconstruction for urinary continence, posterior musculofascial reconstruction was significant-

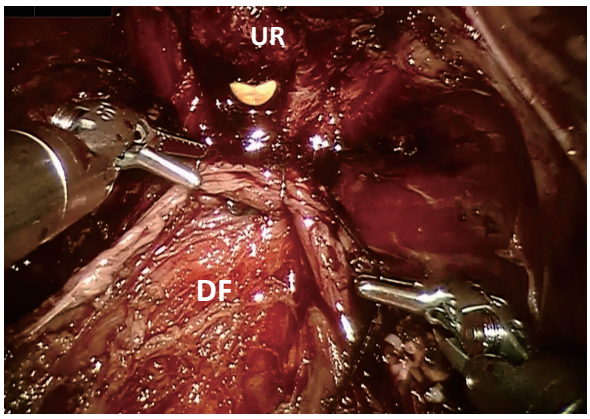

Fig. 3. Representative photograph of posterior reconstruction of Denonvilliers' fascia by using modified Rocco technique
Disconnected rhabdosphincter in the posterior aspect of the urethra and Denonvillers' fascia in the bladder neck were attached to enhance the suspension of the posterior aspect of the urethra and prevention of shortening of the membranous urethra.
UR ; urethra, DF ; Denonvilliers' fascia

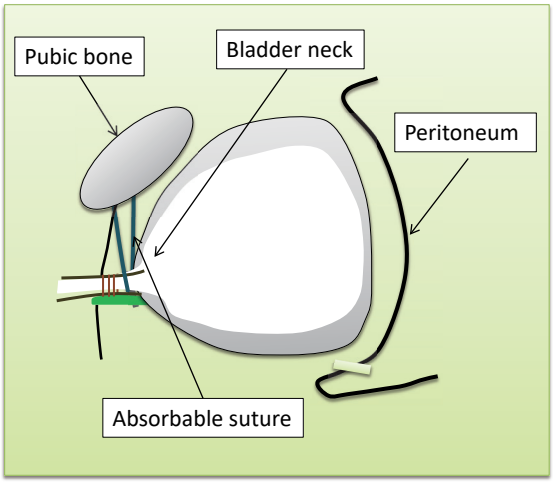

Fig. 4. Bladder neck suspension technique
Bladder neck is lifted by absorbable suture situated under the vesicourethral anastomotic site. This absorbable suture was fixed at the posterior part of the pubic bone in the periosteum.

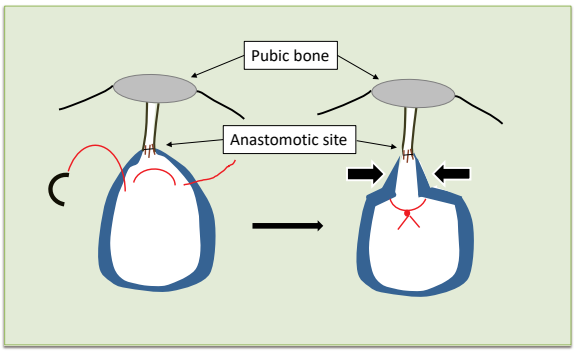

Fig. 5. Bladder neck plication technique
Bladder neck was plicated by running stich at the 2 cm proximal site of vesicourethral anastomosis.

ly associated with early acquisition of urinary continence just 1 month after radical prostatectomy[16]. The mechanism for acquisition of urinary continence by posterior musculofascial reconstruction was that, in association with the disconnected rhabdosphincter in the posterior aspect of the urethra and Denonvillers' fascia in the bladder neck, enhancement of suspension of the posterior aspect of the urethra and prevention of shortening of the membranous urethra by decreased tugging of the urethra in the caudal direction were achieved. To obtain further early acquisition of urinary continence, we developed a new technique for posterior reconstruction using peritoneum for additional support of the posterior aspect both of the urethra and the bladder neck. In this new technique, urinary incontinence was significantly improved at 1 month after RARP, compared with the usual posterior reconstruction using Denonvillers' fascia. In addition, there were no obvious adverse events and no elongation of operative time with this new technique.

With respect to "reinforcement" of anatomical structures in the pelvis, we developed a bladder neck sling suspension technique during RARP (Figure 4)[17]. This new suspension procedure was significantly involved in the early acquisition of urinary continence[17]. Lee *et al.* also reported the usefulness for early acquisition of urinary continence with the bladder neck plication technique during RARP (Figure 5)[18]. However, another group conducted a randomized study of the bladder neck plication technique for the early acquisition of urinary continence[19] ; they found no benefit for urinary continence in the plication group. Therefore, the effect of the bladder plication technique for urinary continence remains controversial.

3. The effect of sutures for urinary continence during vesicourethral anastomosis

Vesicourethral anastomosis for LRP or RARP is usually performed using running sutures in many institutions (Figure 6), because the use of interrupted sutures is more difficult in LRP or RARP than in ORP[20-22]. One of the drawbacks of using running sutures in vesicourethral anastomosis is easy slippage of the suture during the procedure[22]. A polyglyconate, unidirectional barbed synthetic absorb-

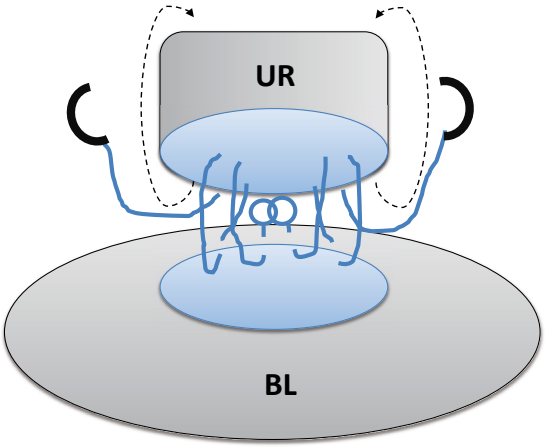

Fig. 6. Vesicourethral anastomosis by using running suture
Vesicourethral anastomosis for laparoscopic radical prostatectomy or robot-assisted radical prostatectomy is usually performed using running sutures in many institutions. This anastomosis technique represents the Van Velthoven stitch.
UR ; urethra, BL ; bladder

able suture (V-Loc Wound Closure Device ; Covidien, Mansfield, MA) consists of a unidirectional barbed absorbable thread. The barbs are present at regular intervals throughout the strand, thereby preventing slippage of the suture, precluding the need for assistance and eliminating the need for knot tying. Therefore, the unidirectional barbed suture has been preferred for vesicourethral anastomosis in LRP or RARP, and several reports have demonstrated excellent perioperative outcomes with respect to shortening of the vesicourethral anastomosis time[22,23].

However, regarding tissue damage associated with barbed sutures, an increasing number of reports has cited a risk of small bowel obstruction after laparoscopic gastrointestinal tract surgery[24,25]. Our study showed that, after RARP, barbed sutures during vesicourethral anastomosis induced more severe tissue damage as seen on MRI (Figures 7) and greater transient aggravation of quality of life (QOL) and lower urinary tract function than non-barbed sutures[26]. The present findings suggest that using non-barbed sutures during vesicourethral anastomosis may facilitate earlier acquisition of urinary QOL and urinary continence.

4. Patient factors and postoperative pelvic anatomical features for post-prostatectomy incontinence

Body mass index (BMI), prostate volume,

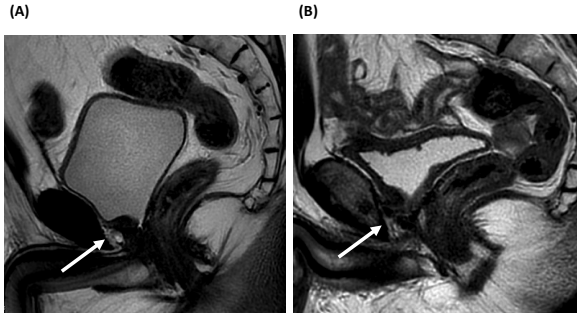

Fig. 7. Postoperative urethral and periurethral tissue on sagittal T2-weighted images from postoperative magnetic resonance imaging (MRI).
(A) Mild damage to the urethra and surrounding tissue.
(B) Severe damage to the urethra and surrounding tissue.

Charlson comorbidity index, age, and so on have been shown to be predictors of delayed recovery of urinary continence after radical prostatectomy[2]. In recently developed nomograms for predicting the recovery of urinary continence after radical prostatectomy, preoperative membranous urethral length, surgical modality (RARP), and age (younger age) were important factors for early urinary continence[27]. In our study, 1) BMI $\geq$ 26 kg/m^2, 2) prostate volume $\geq$ 70 mL, 3) eGFR $\leq$ 60 mL/min, and 4) Charlson comorbidity index $\geq$ 2 points were predictors of delayed recovery of urinary continence after RARP[28]. Because the above-mentioned factors 1)-4) were considered to negatively affect each other for the recovery of urinary continence, urinary incontinence has been significantly prolonged in patients with several of the above-mentioned factors.

The Charlson comorbidity index was primarily developed to predict patients' survival based on the sum of scores composed of patients' comorbidities affecting their survival[29]. This index was found to be significantly correlated with overall survival after radical prostatectomy[30]. Therefore, our study suggests that a Charlson comorbidity index of more than 2 points was not only a risk factor for overall survival after radical prostatectomy, but also a risk factor for delayed recovery of urinary continence after radical prostatectomy. In our institution, informed consent, focusing on the possibility of prolonged urinary incontinence after radical prostatectomy, is obtained from such high-risk patients. Furthermore, additional surgical procedures for alleviating post-prostatectomy incontinence, i.e., total reconstruction, might be needed, as suggested by Nuguyan *et al.*[31].

We also investigated the factors contributing to

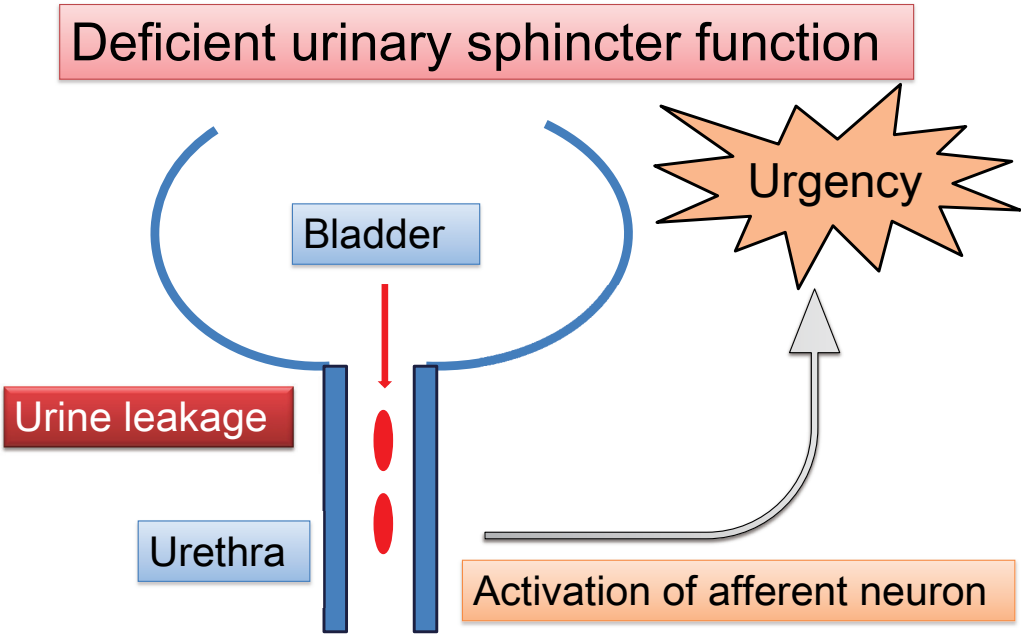

Fig. 8. Putative mechanism of de novo overactive bladder after radical prostatectomy induced by urinary pooling inside the urethra
Urinary leakage into the urethra owing to deficient urethral sphincter function stimulates afferent nerve activity, resulting in inducing urgency after radical prostatectomy.

early recovery of urinary continence after radical prostatectomy from the perspective of postoperative urethral and vesical anatomical features[12,32]. Postoperative membranous urethral length, descent of the bladder neck, and atony of the external urethral sphincter on postoperative cystourethrography are significantly associated with post-prostatectomy incontinence. In addition, a study of postoperative pelvic anatomical features on MRI demonstrated that urinary pooling inside the urethra on postoperative MRI was significantly associated with urgency after radical prostatectomy[32]. Therefore, preservation of the nerves involved in continence to prevent inflow of urine into the urethra was recommended from the perspective of averting de novo overactive bladder (OAB) after radical prostatectomy (Figure 8). Thus, we could predict which patients would have prolonged post-prostatectomy incontinence and de novo OAB based on both patients' factors and postoperative pelvic anatomical features.

5. Association between post-prostatectomy incontinence and nocturia

The causes of post-prostatectomy incontinence are considered to be decreased sphincter function[33], decreased maximum bladder capacity[34], de novo OAB, and so on[35]. The same underlying mechanism that induces post-prostatectomy incontinence might lead to nocturia after radical prostatectomy. We investigated the effect of post-prostatectomy incontinence on nocturia after radical prostatectomy[36]. Our study demonstrated that, although the number of nocturia episodes was not significantly different between the continent and incontinent patients after radical prostatectomy, nocturia-specific QOL was significantly worse in incontinent patients. In incontinent patients after radical prostatectomy, other than the number of nocturia episodes, psychological stress might worsen nocturia-specific QOL. Therefore, prevention of post-prostatectomy incontinence might be important to avoid aggravating nocturia-specific QOL.

6. Effects of medication on urinary incontinence after radical prostatectomy

Several studies investigated the effects of medications on urinary incontinence after radical prostatectomy[27,28]. Bianco *et al.* performed a randomized, double-blind, multicenter study investigating the efficacy of solifenacin succinate in 640 patients with urinary continence after RARP[37]. Although the primary end point, which was the time from the day of the first dose to the day of urinary continence, showed no significant difference between the drug and control groups, a significant increase of the proportion of continent patients at the end of study, a

significant decrease of the average change of number of pads per day, and a significant improvement of QOL were achieved in the drug-administration group as secondary endpoints. Shim *et al.* conducted a prospective, randomized, controlled study to elucidate the therapeutic effect of solifenacin succinate on recovery from voiding dysfunction after radical prostatectomy in 78 men with clinically localized prostate cancer[38]. They concluded that solifenacin succinate might result in early recovery of urinary incontinence and prevent worsening of QOL, which might be attributed to increased bladder capacity after drug administration. From these above-mentioned studies, medication was considered to provide a certain level of effect to decrease urinary incontinence and improve QOL after radical prostatectomy.

7. Efficacy of pelvic floor muscle training for post-prostatectomy incontinence

One of the conservative management techniques for early acquisition of urinary continence after radical prostatectomy is pelvic floor muscle training. In our institution, preoperative pelvic floor muscle training is given to almost all patients who undergo RARP. Anderson *et al.* recently reported a systematic review to elucidate the effectiveness of conservative management including pelvic floor muscle training for early acquisition of urinary continence after radical prostatectomy[39]. Fifty trials were investigated in their systematic review. The trials included 4,717 men, of whom 2,736 had an active conservative intervention. This systematic review did not demonstrate the usefulness of conservative management for post-prostatectomy incontinence because urinary incontinence improved with time regardless of the type of conservative management. The causes why this systematic review did not demonstrate the superiority of conservative management were that a wide variety of conservative therapies, of evaluation methods of urinary continence, and of populations evaluated were included in the review. However, because pelvic floor muscle training was not demonstrated to be invalid for early acquisition of urinary continence after radical prostatectomy, less invasive pelvic floor muscle training should be continued at the institutions that have already introduced it.

8. The effect of pad usage for post-prostatectomy incontinence on urinary QOL after radical prostatectomy

To date, counts of pads for protection against urinary incontinence have been used as an objective measure of the severity of urinary incontinence[40-43]. However, there have been no reports regarding the relationship between pad usage and urinary QOL after radical prostatectomy. Our study showed that increases in the frequency of pad exchange and pad wetness had a significantly negative effect on urinary QOL after RARP in the early postoperative period[44]. Although we predicted that most patients after RARP would select the "liner-type" pads due to a sense of shame associated with wearing "diaper-type" pads due to their lack of discreetness, 39% (35/90) of patients selected "diaper-type" pads for post-prostatectomy incontinence in the early postoperative period. Moreover, there was no significant difference in urinary QOL between patients with "liner-type" pads and patients with "diaper-type" pads. Because patients were informed of the occurrence of urinary incontinence in the early postoperative period and about its improvement with time, most patients might not be bothered about the temporary wearing of "diaper-type" pads in the early postoperative period. However, there is a possibility that not only pad usage, i.e., pad form and pad size, but also wearing pads in itself[45,46], could affect urinary QOL in the late postoperative period after radical prostatectomy.

9. Several problems in the evaluation methods of post-prostatectomy incontinence

There are several issues related to the evaluation methods for post-prostatectomy incontinence. First, there are no obvious criteria for post-prostatectomy incontinence. Although the number of pad exchanges is an objective measure of the severity of urinary incontinence in many studies[40-43], several studies reported that pad count was a poor measure of the severity of urinary incontinence[47-49]. In addition, as we mentioned above (see Section 8), many kinds of pads were used in the early postoperative period after radical prostatectomy[44]. Thus, it is possible that the volume of urinary incontinence would be different even in patients who exchanged the same number of pads per day.

Second, although a longer duration of pad test is a reliable measure of urinary continence, a longer duration of pad test decreases patients' compli-

ance[50]. Looking at the pad test in a comprehensive manner, a 24-h pad test might be the most appropriate for evaluating post-prostatectomy incontinence. However, in our institution, although the 1-h pad test was performed in almost all patients after radical prostatectomy under the close scrutiny of an expert nurse, only half of the patients performed the 24-h pad test regardless of the physician's reminders to do so at the time of every visit to the outpatient clinic. The completion rate of the 24-h pad test in our present cohort was consistent with that of another study[50].

Finally, because the perception of the severity of urinary incontinence differs in each patient, it is possible that increased urinary incontinence is not always correlated with decreased QOL as evaluated by patient-reported outcomes[44]. Therefore, if urinary incontinence were only judged by QOL, the volume of urinary incontinence could not be evaluated objectively. Thus, because there are several limitations in the evaluation method of post-prostatectomy incontinence, urinary continence should be judged by the number of pad exchanges per day, the pad test, and a QOL questionnaire in an integrated fashion[12,44].

10. The effect of radical prostatectomy on postoperative LUTS

Although patients who undergo radical prostatectomy have preoperative LUTS at a relatively constant rate, LUTS has gradually improved with time after radical prostatectomy[51-53]. However, the mechanism of improvement of LUTS after radical prostatectomy has not yet been fully clarified. We demonstrated that improvements of LUTS and lower urinary tract dysfunction were seen with acquisition of the vesical adaptation response to diuresis after RARP in patients with preoperative LUTS[54].

On the other hand, some cases may require a long period for resolution of LUTS after radical prostatectomy[55]. However, the causes of protracted voiding symptoms after radical prostatectomy have yet to be clarified. We investigated the effect of atherosclerosis, which was associated with the occurrence of benign prostatic hyperplasia and male LUTS[56,57], on the resolution of LUTS after radical prostatectomy. The result was that atherosclerosis delayed the improvement of both voiding symptoms and voiding function after RARP, leading to aggravation of QOL in the early postoperative period[58]. Therefore, we demonstrated that atherosclerosis might be a predictor of slower recovery from transient lower urinary tract dysfunction immediately after RARP.

As seen from the above, while several studies demonstrated that RARP provides earlier acquisition of urinary continence[2,59-61], recent attention has shifted the focus to the effect of RARP on lower urinary tract function and LUTS[62-65]. Thus, early improvement of post-prostatectomy incontinence and LUTS after radical prostatectomy are important in the RARP era.

Conclusions

In the RARP era, high levels of good postoperative outcomes for urinary continence after radical prostatectomy have been expected. The ideal outcome would be quick recovery of post-prostatectomy incontinence and pad-free status for all patients. To achieve this ideal, it goes without saying that surgical procedures are the most important aspect. However, in fact, there are individual variabilities in post-prostatectomy incontinence despite the same surgical procedures.

It is important for patients at high risk of post-prostatectomy incontinence to be given information about delayed recovery of post-prostatectomy incontinence. Medications and appropriate pad usage might sometimes be helpful for patients with post-prostatectomy incontinence. Not only surgical procedures, but also a comprehensive approach, are important for post-prostatectomy incontinence.

References

1. Sammon JD, Sharma P, Trinh QD, *et al.* Predictors of immediate continence following robot-assisted radical prostatectomy. J Endourol, **27** : 442, 2013.
2. Ficarra V, Novara G, Rosen RC, *et al.* Systematic review and meta-analysis of studies reporting urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol, **62 :** 405, 2012.
3. De Carlo F, Celestino F, Verri C, *et al.* Retropubic, laparoscopic, and robot-assisted radical prostatectomy : surgical, oncological, and functional outcomes : a systematic review. Urol Int, **93 :** 373, 2014.
4. Haglind E, Carlsson S, Stranne J, *et al.* Urinary Incontinence and Erectile Dysfunction After Robotic Versus Open Radical Prostatectomy : A Prospective, Controlled, Nonrandomised Trial. Eur Urol, **68 :** 216, 2015.
5. Yaxley JW, Coughlin GD, Chambers SK, *et al.* Robot-assisted laparoscopic prostatectomy versus

open radical retropubic prostatectomy : early outcomes from a randomised controlled phase 3 study. Lancet, **388 :** 1057, 2016.
6. Ferronha F, Barros F, Santos VV, *et al.* Is there any evidence of superiority between retropubic, laparoscopic or robot-assisted radical prostatectomy ? Int Braz J Urol, **37 :** 146, 2011.
7. Ahlering TE, Skarecky D, Lee D, *et al.* Successful transfer of open surgical skills to a laparoscopic environment using a robotic interface : initial experience with laparoscopic radical prostatectomy. J Urol, **170 :** 1738, 2003.
8. Good DW, Stewart GD, Laird A, *et al.* A Critical Analysis of the Learning Curve and Postlearning Curve Outcomes of Two Experience- and Volume-Matched Surgeons for Laparoscopic and Robot-Assisted Radical Prostatectomy. J Endourol, **29 :** 939, 2015.
9. Sumitomo M, Kanao K, Kato Y, *et al.* Comparative investigation on clinical outcomes of robot-assisted radical prostatectomy between experienced open prostatic surgeons and novice open surgeons in a laparoscopically naive center with a limited caseload. Int J Urol, **22 :** 469, 2015.
10. Kojima Y, Takahashi N, Haga N, *et al.* Urinary incontinence after robot-assisted radical prostatectomy : pathophysiology and intraoperative techniques to improve surgical outcome. Int J Urol, **20 :** 1052, 2013.
11. Yanagida T, Koguchi T, Hata J, *et al.* Current techniques to improve outcomes for early return of urinary continence following robot-assisted radical prostatectomy. Fukushima J Med Sci, **60 :** 1, 2014.
12. Haga N, Ogawa S, Yabe M, *et al.* Factors Contributing to Early Recovery of Urinary Continence Analyzed by Pre- and Postoperative Pelvic Anatomical Features at Robot-Assisted Laparoscopic Radical Prostatectomy. J Endourol, **29 :** 683, 2015.
13. Haga N, Hata J, Matsuoka K, *et al.* The impact of nerve-sparing robot-assisted radical prostatectomy on lower urinary tract function : Prospective assessment of patient-reported outcomes and frequency volume charts. Neurourol Urodyn, 2017.
14. Reeves F, Preece P, Kapoor J, *et al.* Preservation of the Neurovascular Bundles Is Associated with Improved Time to Continence After Radical Prostatectomy But Not Long-term Continence Rates : Results of a Systematic Review and Meta-analysis. Eur Urol, **68 :** 692, 2015.
15. Rocco F, Carmignani L, Acquati P, *et al.* Early continence recovery after open radical prostatectomy with restoration of the posterior aspect of the rhabdosphincter. Eur Urol, **52 :** 376, 2007.
16. Rocco B, Cozzi G, Spinelli MG, *et al.* Posterior musculofascial reconstruction after radical prostatectomy : a systematic review of the literature. Eur Urol, **62 :** 779, 2012.
17. Kojima Y, Hamakawa T, Kubota Y, *et al.* Bladder neck sling suspension during robot-assisted radical prostatectomy to improve early return of urinary continence : a comparative analysis. Urology, **83 :** 632, 2014.
18. Lee DI, Wedmid A, Mendoza P, *et al.* Bladder neck plication stitch : a novel technique during robot-assisted radical prostatectomy to improve recovery of urinary continence. J Endourol, **25 :** 1873, 2011.
19. Choi SK, Park S, Ahn H. Randomized clinical trial of a bladder neck plication stitch during robot-assisted radical prostatectomy. Asian J Androl, **17 :** 304, 2015.
20. Van Velthoven RF, Ahlering TE, Peltier A, *et al.* Technique for laparoscopic running urethrovesical anastomosis : the single knot method. Urology, **61 :** 699, 2003.
21. Williams SB, Alemozaffar M, Lei Y, *et al.* Randomized controlled trial of barbed polyglyconate versus polyglactin suture for robot-assisted laparoscopic prostatectomy anastomosis : technique and outcomes. Eur Urol, **58 :** 875, 2010.
22. Li H, Liu C, Zhang H, *et al.* The Use of Unidirectional Barbed Suture for Urethrovesical Anastomosis during Robot-Assisted Radical Prostatectomy : A Systematic Review and Meta-Analysis of Efficacy and Safety. PLoS One, **10 :** e0131167, 2015.
23. Zorn KC, Trinh QD, Jeldres C, *et al.* Prospective randomized trial of barbed polyglyconate suture to facilitate vesico-urethral anastomosis during robot-assisted radical prostatectomy : time reduction and cost benefit. BJU Int, **109 :** 1526, 2012.
24. Sakata S, Kabir S, Petersen D, *et al.* Are we burying our heads in the sand ? Preventing small bowel obstruction from the V-loc(R) suture in laparoscopic ventral rectopexy. Colorectal Dis, **17 :** O180, 2015.
25. Oor J, de Castro S, van Wagensveld B. V-loc capable of grasping surrounding tissue causes obstruction at the jejunojejunostomy after Roux-en-Y laparoscopic gastric bypass. Asian J Endosc Surg, **8 :** 209, 2015.
26. Haga N, Kurita N, Yanagida T, *et al.* Effects of barbed suture during robot-assisted radical prostatectomy on postoperative tissue damage and longitudinal changes in lower urinary tract outcome. Surg Endosc, 2017.
27. Jeong SJ, Yeon JS, Lee JK, *et al.* Development and validation of nomograms to predict the recovery of urinary continence after radical prostatectomy : comparisons between immediate, early, and late continence. World J Urol, **32 :** 437, 2014.

28. Haga N, Yanagida T, Sato Y, *et al.* [Approaches for the acquisition of urinary continence after radical prostatectomy]. Nihon Rinsho, **74 Suppl 3 :** 461, 2016.
29. Quan H, Li B, Couris CM, *et al.* Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. Am J Epidemiol, **173 :** 676, 2011.
30. Lee JY, Kang HW, Rha KH, *et al.* Age-adjusted Charlson comorbidity index is a significant prognostic factor for long-term survival of patients with high-risk prostate cancer after radical prostatectomy : a Bayesian model averaging approach. J Cancer Res Clin Oncol, **142 :** 849, 2016.
31. Nguyen L, Jhaveri J, Tewari A. Surgical technique to overcome anatomical shortcoming : balancing post-prostatectomy continence outcomes of urethral sphincter lengths on preoperative magnetic resonance imaging. J Urol, **179 :** 1907, 2008.
32. Haga N, Ogawa S, Yabe M, *et al.* Association between postoperative pelvic anatomic features on magnetic resonance imaging and lower tract urinary symptoms after radical prostatectomy. Urology, **84 :** 642, 2014.
33. Dubbelman YD, Groen J, Wildhagen MF, *et al.* Urodynamic quantification of decrease in sphincter function after radical prostatectomy : relation to postoperative continence status and the effect of intensive pelvic floor muscle exercises. Neurourol Urodyn, **31 :** 646, 2012.
34. Song C, Lee J, Hong JH, *et al.* Urodynamic interpretation of changing bladder function and voiding pattern after radical prostatectomy : a long-term follow-up. BJU Int, **106 :** 681, 2010.
35. Matsukawa Y, Hattori R, Yoshikawa Y, *et al.* Laparoscopic versus open radical prostatectomy : urodynamic evaluation of vesicourethral function. Int J Urol, **16 :** 393, 2009.
36. Haga N, Aikawa K, Hoshi S, *et al.* Postoperative urinary incontinence exacerbates nocturia-specific quality of life after robot-assisted radical prostatectomy. Int J Urol, **23 :** 873, 2016.
37. Bianco FJ, Albala DM, Belkoff LH, *et al.* A randomized, double-blind, solifenacin succinate versus placebo control, phase 4, multicenter study evaluating urinary continence after robotic assisted radical prostatectomy. J Urol, **193 :** 1305, 2015.
38. Shim M, Kim J, Park S, *et al.* The therapeutic effect of solifenacin succinate on the recovery from voiding dysfunction after radical prostatectomy in men with clinically localized prostate cancer : a prospective, randomized, controlled study. Urology, **85 :** 1123, 2015.
39. Anderson CA, Omar MI, Campbell SE, *et al.* Conservative management for postprostatectomy urinary incontinence. Cochrane Database Syst Rev, **1 :** Cd001843, 2015.
40. Seweryn J, Bauer W, Ponholzer A, *et al.* Initial experience and results with a new adjustable transobturator male system for the treatment of stress urinary incontinence. J Urol, **187 :** 956, 2012.
41. Kowalik CG, Delong JM, Mourtzinos AP. The adVance transobturator male sling for post-prostatectomy incontinence : Subjective and objective outcomes with 3 years follow up. Neurourol Urodyn, 2013.
42. Bochove-Overgaauw DM, Schrier BP. An adjustable sling for the treatment of all degrees of male stress urinary incontinence : retrospective evaluation of efficacy and complications after a minimal followup of 14 months. J Urol, **185 :** 1363, 2011.
43. Lebret T, Cour F, Benchetrit J, *et al.* Treatment of postprostatectomy stress urinary incontinence using a minimally invasive adjustable continence balloon device, ProACT : results of a preliminary, multicenter, pilot study. Urology, **71 :** 256, 2008.
44. Haga N, Yanagida T, Yabe M, *et al.* Timing of Urinary Pad Exchanges Was the Most Important Factor Affecting Quality of Life in the Early Postoperative Period After Robot-Assisted Laparoscopic Radical Prostatectomy. J Endourol, **29 :** 1044, 2015.
45. Wallerstedt A, Carlsson S, Nilsson AE, *et al.* Pad use and patient reported bother from urinary leakage after radical prostatectomy. J Urol, **187 :** 196, 2012.
46. Liss MA, Osann K, Canvasser N, *et al.* Continence definition after radical prostatectomy using urinary quality of life : evaluation of patient reported validated questionnaires. J Urol, **183 :** 1464, 2010.
47. Tsui JF, Shah MB, Weinberger JM, *et al.* Pad count is a poor measure of the severity of urinary incontinence. J Urol, **190 :** 1787, 2013.
48. Dylewski DA, Jamison MG, Borawski KM, *et al.* A statistical comparison of pad numbers versus pad weights in the quantification of urinary incontinence. Neurourol Urodyn, **26 :** 3, 2007.
49. Nitti VW, Mourtzinos A, Brucker BM. Correlation of Patient Perception of Pad Use with Objective Degree of Incontinence Measured by Pad Test in Men with Post Prostatectomy Incontinence : The SUFU Pad Test Study. J Urol, 2014.
50. Groutz A, Blaivas JG, Chaikin DC, *et al.* Noninvasive outcome measures of urinary incontinence and lower urinary tract symptoms : a multicenter study of micturition diary and pad tests. J Urol, **164 :** 698, 2000.
51. Bayoud Y, de la Taille A, Ouzzane A, *et al.* International Prostate Symptom Score is a predictive factor of lower urinary tract symptoms after radical

prostatectomy. Int J Urol, **22 :** 283, 2015.
52. Namiki S, Ishidoya S, Ito A, *et al.* Quality of life after radical prostatectomy in Japanese men : a 5-Year follow up study. Int J Urol, **16 :** 75, 2009.
53. Geraerts I, Van Poppel H, Devoogdt N, *et al.* Prospective evaluation of urinary incontinence, voiding symptoms and quality of life after open and robot-assisted radical prostatectomy. BJU Int, **112 :** 936, 2013.
54. Haga N, Aikawa K, Hoshi S, *et al.* The Effect of the Vesical Adaptation Response to Diuresis on Lower Urinary Tract Symptoms after Robot-Assisted Laparoscopic Radical Prostatectomy : A Pilot Proof of Concept Study. PLoS One, **11 :** e0159514, 2016.
55. Gordon A, Skarecky DW, Ahlering T. Long-term Outcomes in Severe Lower Urinary Tract Symptoms in Men Undergoing Robotic-assisted Radical Prostatectomy. Urology, 2014.
56. Azab S. The impact of atherosclerosis on lower urinary tract function. Aging Male, **16 :** 108, 2013.
57. Takahashi N, Shiomi H, Kushida N, *et al.* Obstruction alters muscarinic receptor-coupled RhoA/Rho-kinase pathway in the urinary bladder of the rat. Neurourol Urodyn, **28 :** 257, 2009.
58. Yabe M, Haga N, Ogawa S, *et al.* Atherosclerosis as a predictor of delayed recovery from lower urinary tract dysfunction after robot-assisted laparoscopic radical prostatectomy. Neurourol Urodyn, **35 :** 920, 2016.
59. Moran PS, O'Neill M, Teljeur C, *et al.* Robot-assisted radical prostatectomy compared with open and laparoscopic approaches : a systematic review and meta-analysis. Int J Urol, **20 :** 312, 2013.
60. Porpiglia F, Morra I, Lucci Chiarissi M, *et al.* Randomised controlled trial comparing laparoscopic and robot-assisted radical prostatectomy. Eur Urol, **63 :** 606, 2013.
61. Gandaglia G, Suardi N, Gallina A, *et al.* How to optimize patient selection for robot-assisted radical prostatectomy : functional outcome analyses from a tertiary referral center. J Endourol, **28 :** 792, 2014.
62. Froehner M, Koch R, Leike S, *et al.* Urinary tract-related quality of life after radical prostatectomy : open retropubic versus robot-assisted laparoscopic approach. Urol Int, **90 :** 36, 2013.
63. Wang L, Chung SF, Yip SK, *et al.* The natural history of voiding function after robot-assisted laparoscopic radical prostatectomy. Urol Oncol, **29 :** 177, 2011.
64. Kadono Y, Ueno S, Iwamoto D, *et al.* Chronological Urodynamic Evaluation of Changing Bladder and Urethral Functions After Robot-assisted Radical Prostatectomy. Urology, 2015.
65. Yanagiuchi A, Miyake H, Tanaka K, *et al.* Significance of preoperatively observed detrusor overactivity as a predictor of continence status early after robot-assisted radical prostatectomy. Asian J Androl, **16 :** 869, 2014.