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ORIGINAL ARTICLE

Extended versus limited pelvic lymph node dissection during bilateral nerve-sparing radical prostatectomy and its effect on continence and erectile function recovery: long-term results and trifecta rates of a comparative analysis

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Abstract

Purpose To assess continence and erectile function (EF) recovery of extended pelvic lymph node dissection (ePLND) versus limited PLND (lPLND) after bilateral nerve-sparing radical prostatectomy (BNSRP).

Methods Consecutive prostate cancer (PCa) patients undergoing BNSRP were stratified according to D'Amico into two groups: low-risk-PCa lPLND (obturator) and intermediate-/high-risk-PCa ePLND (obturator, external iliac artery, internal iliac artery, common iliac artery). Continence (no pad/one safety pad) and EF (IIEF-5 $\geq$ 17) recovery were assessed. Patients with phosphodiesterase type 5 inhibitors, neoadjuvant/adjuvant therapy, positive lymph nodes or positive surgical margins were excluded.

Results From January 2007 to May 2012, a total 966 consecutive patients were included. Four hundred and sixty patients met the inclusion/exclusion criteria: 262 patients had ePLND and 198 patients had lPLND. Mean number of lymph nodes was 20.4 (range 10–65) and 4.7 (range 0–10), respectively ($p < 0.001$). Continence and spontaneous EF recovery after 12 months were 89.7 versus 93.4 % and 40.4 versus 47.5 %, respectively (all $p > 0.05$). Patient age at surgery ($p = 0.001$), preoperative EF ($p < 0.001$) and pathological tumor stage ($p = 0.008$), but not ePLND ($p = 0.561$), were independent predictors of EF recovery. No association was detected for continence recovery. Seven-year BCR-free survival for pT2 PCa was 100 and 94.8 % in lPLND and ePLND, respectively ($p = 0.011$). For pT3 PCa, this was 94.7 and 81.2 %, respectively ($p = 0.287$). At 2 years, the trifecta of continence, potency and recurrence freedom was achieved in 47.5 and 44.1 % in lPLND and ePLND, respectively ($p = 0.451$).

Conclusions ePLND is not associated with increased risk of postoperative incontinence or erectile dysfunction. Only patient age at surgery, preoperative EF and pathological tumor stage represent predictors of EF recovery.

Keywords Continence · Erectile function · Extended lymph node dissection · Radical prostatectomy · Trifecta

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Introduction

Radical prostatectomy (RP) represents standard surgical treatment in patients with localized prostate cancer (PCa) and life expectancy >10 years of age and should preferably be performed using a nerve-sparing (ns) technique [1]. Besides oncological outcomes, RP might be associated with urinary incontinence and erectile dysfunction (ED), which both represent functional impairments in regard to postoperative quality of life [2, 3]. According to recent guidelines and reports in the literature, extended pelvic lymph node dissection (ePLND) is recommended in intermediate- and high-risk PCa according to D'Amico [4, 5]. When ePLND is performed, potential damages to neural fibers can occur, particularly during the dissection of the internal iliac area, which is contiguous to the pelvic plexus [6]. In this regard, ePLND might be associated with increased risk of postoperative incontinence and ED due to damages to the vegetative pelvic plexus. However, only limited data exist on this issue. There are several studies in the literature, which focus on oncological outcomes after ePLND in intermediate- and high-risk PCa; however, functional data are rarely reported [7–9]. The aim of our study was to assess whether ePLND during bilateral nerve-sparing RP (BNSRP) is associated with an increased risk of postoperative incontinence and ED, compared to limited PLND (lPLND). We moreover, for the first time, provide trifecta rates in patients undergoing ePLND during BNSRP.

Patients and methods

Study population and design

The population of this series consisted of consecutive patients with histopathologically confirmed PCa. All patients underwent open retropubic BNSRP at a single academic center. All the surgeries were performed by the same surgical group, which consisted of five experienced surgeons who all have passed the learning curve of this procedure. During RP, a Rocco stitch was performed in all the patients consistently for reconstruction of the pelvic floor. Patients were generally followed for cancer recurrence, continence and EF recovery, postoperatively with serial PSA measurements, assessment of number of pads and International Index of Erectile Function (IIEF-5) score every 3 months for the first year, every 6 months for the second year, and then annually thereafter. Continence recovery was defined using a no pad or one safety pad (dry at the end of the day) definition. Like in previous studies, the International Index of Erectile Function questionnaire (IIEF-5 $\geq$ 17) was used to assess EF recovery [10, 11]. Preoperative and postoperative assessment of continence and EF was done by means of self-administered questionnaires filled by the patient. In order to provide clear data regarding the effect of ePLND on continence and EF recovery and to avoid any confounding factors, the following were excluded from the analyses: neoadjuvant/adjuvant therapy, positive lymph node disease and positive surgical margins [12]. There are hints in the literature that phosphodiesterase type 5 inhibitors (PDE-5i) may adversely impact biochemical recurrence (BCR) after RP [13]. Therefore, patients using PDE-5i preoperatively or postoperatively were excluded, and only patients with complete and detailed clinicopathological data were included. The principles of the Helsinki Declaration were followed. All patients were informed about the surgical approach and signed written informed consent.

Lymph node dissection templates

Pelvic lymph node dissection was performed according to the preoperative risk classification by D'Amico [4]. Patients with low-risk PCa underwent lPLND (obturator region), whereas patients with intermediate- and high-risk PCa underwent ePLND (obturator region, external iliac artery area, internal iliac artery area, common iliac artery area up to the ureteric crossing). This lymph node dissection template is similar to other study groups [11]. The lymph nodes obtained during RP were sent as separate packages for each region to the pathology department in order to facilitate orientation. In order to avoid any selection bias, all patients in the respective risk groups invariably were subject to the same lymph node dissection templates. In this regard, it should be mentioned that according to existing guidelines lymph node dissection is not recommended in low-risk PCa. The reason to include only the obturator region in the lymph node dissection template of low-risk PCa patients in our study was to provide a minimal lymph node staging in this risk group. Another approach would have been to include also the external iliac nodes in this group. However, we decided to include the latter lymph nodes in the ePLND template as this is also common practice in our institution. It should also be emphasized that practices with regard to PLND in PCa are inconsistent between existing guidelines and institutions, and therefore, no consensus exists about the optimal extent of PLND.

Statistical analysis

Primary endpoints were maintenance of continence/EF. Secondary endpoint was BCR-free survival. BCR was defined as PSA $\geq$ 0.2 ng/ml. Only potent patients were included in the analysis regarding EF recovery. Comparison between lPLND and ePLND with respect to mean age and number of pelvic lymph nodes is made using independent samples *t* test. For between-group comparisons of frequencies, χ^2 tests were used. Survival analyses are performed using Kaplan–Meier method, log-rank test and Cox regression. For influence of several covariates on EF/continence recovery, univariate and multivariate Cox regression analyses were used. Hazard ratio is given with respective 95 % confidence intervals. Any p values are two-sided with significance level of 0.05. Analyses were performed with IBM SPSS statistics version 22.

Results

From January 2007 to May 2012, a total 966 consecutive patients underwent BNSRP and were included in this study. Thirty patients were excluded because of neoadjuvant treatment. One hundred and eighty-four patients were excluded because of lymph node positive disease or positive surgical margins in final pathology, requiring adjuvant treatment. Moreover, one hundred and forty-two patients

Table 1 Clinicopathological characteristics of total evaluable study cohort ($n = 460$ patients)

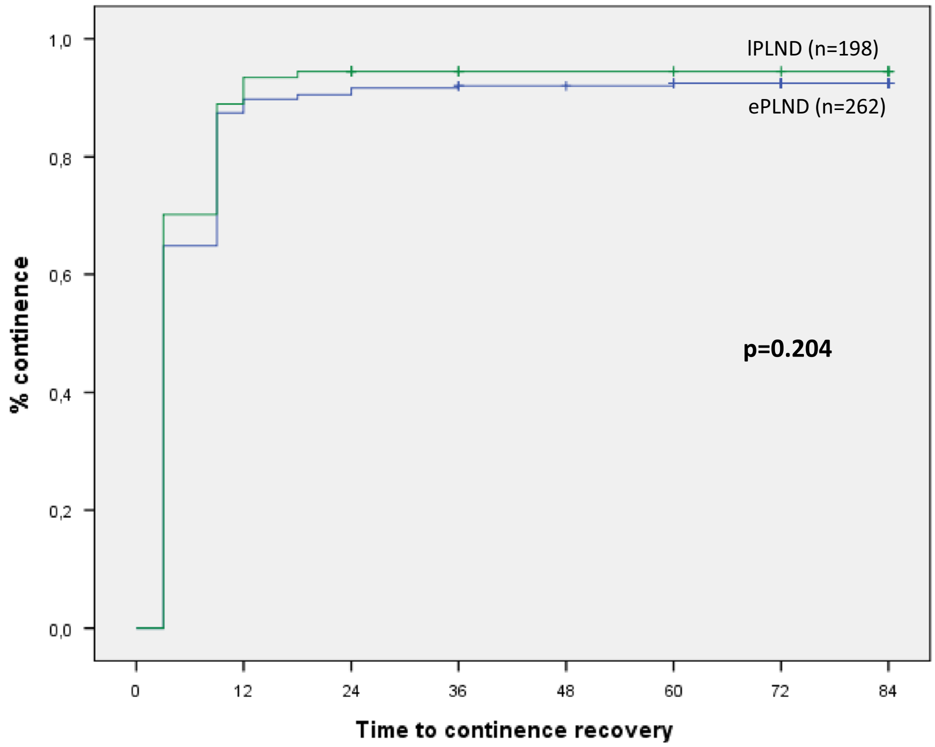
	Total	Extended PLND	Limited PLND	*p* value
Number of patients	460	262 (57.0 %)	198 (43.0 %)	
Mean patient age at surgery with sd (yrs)	64.8 ± 7.6	64.9 ± 7.5	64.6 ± 7.8	0.685
Patient age at surgery (yrs)				0.587
<60	103 (22.4 %)	55 (21.0 %)	48 (24.2 %)	
60–70	235 (51.1 %)	139 (53.0 %)	96 (48.5 %)	
>70	122 (26.5 %)	68 (26.0 %)	54 (27.3 %)	
Mean PSA at diagnosis with sd (ng/ml)	8.3 ± 6.3	9.9 ± 7.8	6.1 ± 1.9	<0.001
Clinical tumor stage				<0.001
≤cT1c	298 (64.8 %)	150 (57.3 %)	148 (74.7 %)	
≥cT2a	162 (35.2 %)	112 (42.7 %)	50 (25.3 %)	
Biopsy Gleason score				<0.001
6	198 (43.0 %)	0	198 (100.0 %)	
7	232 (50.4 %)	232 (88.6 %)	0	
8	21 (4.6 %)	21 (8.0 %)	0	
9	9 (2.0 %)	9 (3.4 %)	0	
Preoperative IIEF-5 score				0.569
No ED (22–25)	133 (28.9 %)	77 (29.4 %)	56 (28.3 %)	
Mild ED (17–21)	102 (22.2 %)	59 (22.5 %)	43 (21.7 %)	
Mild to moderate ED (12–16)	28 (6.1 %)	18 (6.9 %)	10 (5.0 %)	
Moderate ED (8–11)	37 (8.0 %)	24 (9.2 %)	13 (6.6 %)	
Severe ED (1–7)	160 (34.8 %)	84 (32.0 %)	76 (38.4 %)	
Pathological Gleason score				0.016
6	194 (42.2 %)	105 (40.1 %)	89 (44.9 %)	
7	225 (48.9 %)	125 (47.7 %)	100 (50.6 %)	
8–10	41 (8.9 %)	32 (12.2 %)	9 (4.5 %)	
Pathological stage distribution				0.211
pT2	360 (78.3 %)	200 (76.3 %)	160 (80.8 %)	
pT3a	61 (13.3 %)	34 (13.0 %)	27 (13.6 %)	
pT3b	37 (8.0 %)	26 (9.9 %)	11 (5.6 %)	
pT4	2 (0.4 %)	2 (0.8 %)	0	
Mean number of pelvic lymph nodes removed with sd	13.7 ± 11	20.4 ± 9.7	4.7 ± 4	<0.001
Median number of pelvic lymph nodes removed with range	12 [0; 65]	18 [10; 65]	6 [0; 10]	<0.001

Extended PLND: intermediate- and high-risk prostate cancer; limited PLND: low-risk prostate cancer according to D'Amico

PLND pelvic lymph node dissection, *sd* standard deviation, *yrs* years, *PSA* prostate-specific antigen, *IIEF-5* International Index of Erectile Function, 5-item score, *ED* erectile dysfunction

taking PDE-5i preoperatively or postoperatively because of ED were excluded from the analyses. No other treatment of ED was used. Importantly, no other form of penile rehabilitation was employed. This resulted in a cohort of 610 patients. In 460/610 patients (75.4 %), complete and detailed clinicopathological data, including number of pads used and IIEF-5 scores, were available. This represented the total evaluable study cohort ($n = 460$ patients).

Mean follow-up was 53 months; median follow-up was 48 months (range 24–84). Mean patient age was 64.8 years (range 42–80). A total of 262 (57.0 %) patients and 198 (43.0 %) patients underwent ePLND and lPLND, respectively. Mean number of removed lymph nodes was 20.4 (median 18) and 4.7 (median 6) in these groups, respectively ($p < 0.001$). Patients treated with ePLND had significantly higher PSA and clinical tumor stage at diagnosis ($p < 0.001$). Moreover, patients who underwent ePLND had significantly higher pathological Gleason score ($p = 0.016$), whereas pathological tumor stage was not different comparing to patients with lPLND ($p = 0.211$). These data reflect the highly selected and subclassified patient groups, as the ePLND group included intermediate- and high-risk PCa, whereas the lPLND group consisted of low-risk PCa according to D'Amico. Clinicopathological



		begin	1 year	2 years	3 years	4 years	5 years	6 years	7 years
lPLND	C recovery	-	93.4%	94.4%	94.4%	94.4%	94.4%	94.4%	94.4%
	No at risk	198	22	11	7	7	5	4	3
ePLND	C recovery	-	89.7%	91.6%	92%	92%	92.4%	92.4%	92.4%
	No at risk	262	33	25	22	19	18	15	6

Fig. 1 Kaplan–Meier curve of continence recovery in patients with limited (low-risk PCa) and extended (intermediate- and high-risk PCa according to preoperative classification by D'Amico) pelvic lymph node dissection. *C* continence, *lPLND* limited pelvic lymph node dissection, *ePLND* extended pelvic lymph node dissection

characteristics of the evaluable study cohort are given in Table 1.

Impact of extent of PLND on continence recovery

Regarding continence recovery, no significant differences were recorded when patients were stratified according to the extent of PLND. Continence recovery rates at 12 months were 89.7 and 93.4 % in ePLND and lPLND groups, respectively ($p = 0.204$). These findings remained unchanged up to a follow-up of 84 months. Figure 1 shows Kaplan–Meier analysis of continence recovery in patients with ePLND and lPLND. Moreover, no significant differences in continence recovery were found after stratifying patients according to patient age at surgery, preoperative EF or pathological stage and Gleason score. Table 2 shows univariate and multivariate Cox regression analyses predicting continence recovery after BNSRP.

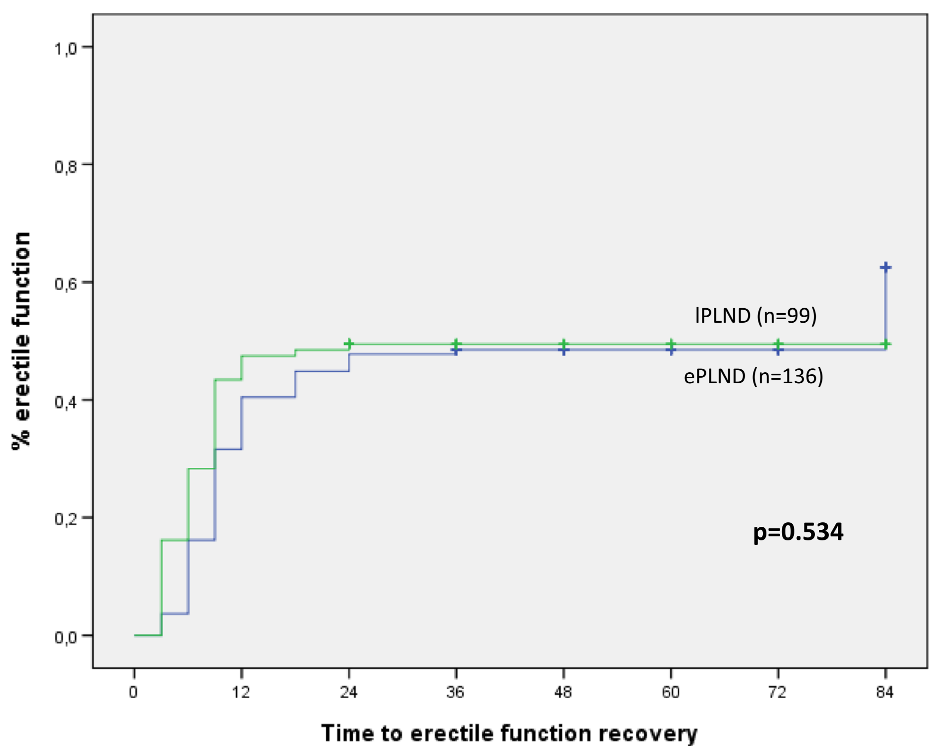
Impact of extent of PLND on erectile function recovery

In regard to preoperative EF, 136/262 patients (51.9 %) and 99/198 patients (50.0 %) with ePLND and lPLND were potent, respectively, and included in the analysis regarding EF recovery. Patients using PDE-5i were excluded. Spontaneous EF recovery rates (without medical help) in ePLND and lPLND groups were 40.4 and 47.5 %, at 12 months, respectively ($p = 0.534$). These findings remained unchanged up to a follow-up of 84 months. Figure 2 shows Kaplan–Meier analysis of spontaneous EF recovery in patients with ePLND and lPLND. Moreover, significant differences in EF recovery were found after stratifying patients according to preoperative erectile status. Patients with no ED (IIEF-5 $\geq$ 22) were more likely to recover EF than patients with baseline mild ED (IIEF-5: 17–21). Furthermore, increasing patient age at surgery was associated with an increased risk of postoperative ED. These results were confirmed in univariate and multivariate analyses,

Table 2 Univariate and multivariate Cox regression analyses predicting continence recovery after bilateral nerve-sparing radical prostatectomy

Predictors	Univariate analyses HR [CI]	*p* value	Multivariate analyses HR [CI]	*p* value
Patient age at surgery	0.99 [0.98; 1]	0.095	0.99 [0.98; 1.01]	0.406
Preoperative IIEF-5 score	–	0.564	–	0.795
No ED versus severe ED	1.22 [0.96; 1.55]	0.101	1.19 [0.91; 1.55]	0.207
Mild ED versus severe ED	1.14 [0.88; 1.48]	0.318	1.11 [0.85; 1.46]	0.437
Mild to moderate ED versus severe ED	1.09 [0.72; 1.66]	0.680	1.11 [0.73; 1.69]	0.634
Moderate ED versus severe ED	1.03 [0.71; 1.5]	0.878	1.05 [0.72; 1.53]	0.807
PSA at diagnosis	1 [0.98; 1.01]	0.639	1 [0.98; 1.01]	0.706
Pathological Gleason score	–	0.607	–	0.523
6 versus 8–10	1.11 [0.78; 1.58]	0.570	1.12 [0.77; 1.64]	0.556
7 versus 8–10	1.01 [0.71; 1.43]	0.974	1 [0.69; 1.44]	0.991
Pathological stage distribution pT3(a/b) + pT4 versus pT2(a/b/c)	1.08 [0.86; 1.36]	0.519	1.16 [0.9; 1.49]	0.245
Limited PLND versus extended PLND	1.08 [0.89; 1.3]	0.444	1.07 [0.87; 1.31]	0.508
Prostate volume	1 [0.99; 1]	0.329	1 [0.99; 1]	0.434

HR hazard ratio, *CI* confidence interval, *IIEF-5* International Index of Erectile Function, 5-item score, *ED* erectile dysfunction, *PSA* prostate-specific antigen, *PLND* pelvic lymph node dissection



		begin	1 year	2 years	3 years	4 years	5 years	6 years	7 years
lPLND	EF recovery	-	47.5%	49.5%	49.5%	49.5%	49.5%	49.5%	49.5%
	No at risk	99	56	51	31	23	18	12	5
ePLND	EF recovery	-	40.4%	47.8%	47.8%	48.5%	48.5%	48.5%	62.6%
	No at risk	136	93	75	71	57	37	26	11

Fig. 2 Kaplan–Meier curve of spontaneous erectile function recovery in patients with limited (low-risk PCa) and extended (intermediate- and high-risk PCa according to preoperative classification by D'Amico) pelvic lymph node dissection. *EF* erectile function, *lPLND* limited pelvic lymph node dissection, *ePLND* extended pelvic lymph node dissection

Table 3 Univariate and multivariate Cox regression analyses predicting erectile function recovery after bilateral nerve-sparing radical prostatectomy

Predictors	Univariate analyses HR [CI]	*p* value	Multivariate analyses HR [CI]	*p* value
Patient age at surgery	0.96 [0.94; 0.98]	0.001	0.97 [0.95; 1]	0.019
Preoperative IIEF-5 score mild ED versus no ED	0.4 [0.26; 0.59]	<0.001	0.44 [0.29; 0.66]	<0.001
PSA at diagnosis	1 [0.98; 1.03]	0.881	1.01 [0.98; 1.04]	0.487
Pathological Gleason score		0.203		0.558
6 versus 8–10	1.86 [0.75; 4.64]	0.181	0.96 [0.36; 2.56]	0.927
7 versus 8–10	1.43 [0.57; 3.58]	0.448	0.78 [0.29; 2.08]	0.622
Pathological stage distribution pT3(a/b) + pT4 versus pT2(a/b/c)	0.41 [0.22; 0.79]	0.008	0.45 [0.22; 0.93]	0.030
Limited PLND versus extended PLND	1.11 [0.77; 1.61]	0.561	1.11 [0.75; 1.63]	0.600
Prostate volume	1 [0.99; 1.01]	0.502	1 [0.99; 1.01]	0.642

HR hazard ratio, *CI* confidence interval, *IIEF-5* International Index of Erectile Function, 5-item score, *ED* erectile dysfunction, *PSA* prostate-specific antigen, *PLND* pelvic lymph node dissection

where only patient age at surgery ($p = 0.001$), preoperative EF ($p < 0.001$) and pathological tumor stage ($p = 0.008$) were independent predictors of postoperative EF recovery. Importantly, the extent of PLND was not associated with decreased EF recovery rates at univariate or multivariate analyses (all $p > 0.5$). Table 3 shows univariate and multivariate Cox regression analyses predicting EF recovery after BNSRP.

Impact of extent of PLND on BCR-free survival and trifecta rates

Seven-year BCR-free survival for pT2 PCa, independent of final Gleason score, was 100 and 94.8 % in patients with lPLND and ePLND, respectively ($p = 0.011$). For pT3 disease, this was 94.7 and 81.2 %, respectively ($p = 0.287$). In order to provide clear results regarding the effect of PLND on functional data, patients with proven BCR who underwent further treatment (radiation therapy and hormonal therapy) were excluded from the analyses regarding continence and EF recovery. Figure 3 shows Kaplan–Meier analyses of BCR-free survival in patients with lPLND (low-risk PCa) and ePLND (intermediate- and high-risk PCa according to D'Amico). At 2 years, the trifecta of continence, potency and freedom from recurrence was achieved in 47.5 and 44.1 % of patients with lPLND and ePLND, respectively ($p = 0.451$). Table 4 shows trifecta rates in lPLND and ePLND groups, according to years after BNSRP.

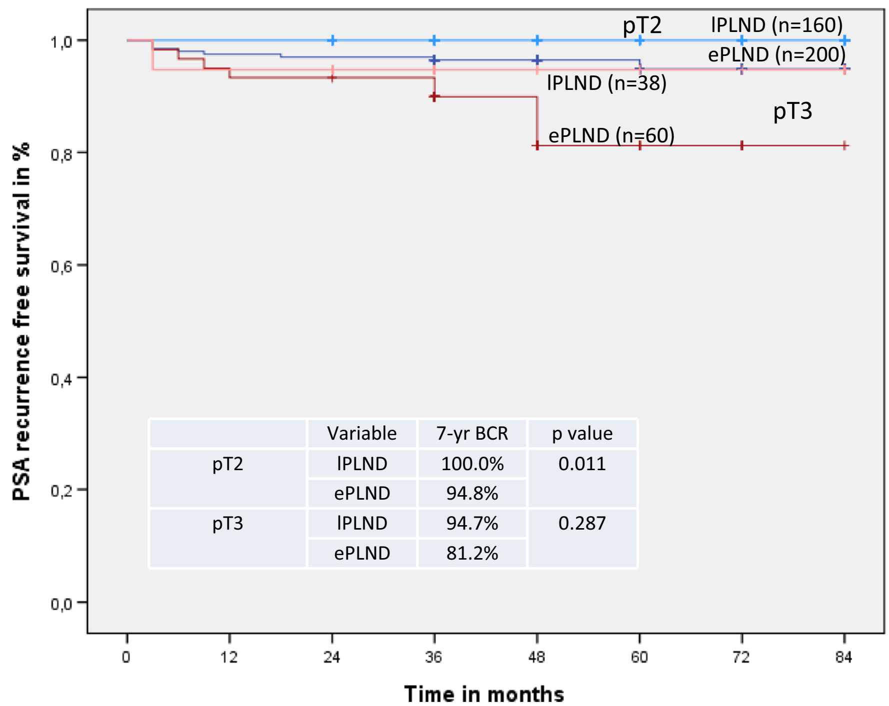
Discussion

Complete cancer resection, urinary continence and EF recovery are the most important outcomes after RP, known as the trifecta [2]. Although there have been various studies published which focus on surgical technique and oncological outcomes after ePLND in PCa, only limited studies are available that report on functional outcomes associated with ePLND [8, 9, 14, 15].

In our study, we employed rigorous exclusion/inclusion criteria in order to provide clear data regarding the effect of ePLND on continence and EF recovery. Moreover, as neoadjuvant or adjuvant/salvage therapies after RP can have a significant effect on oncologic and functional outcomes, patients receiving these treatments were excluded from the study analyses. Patients with, for example, adjuvant radiotherapy after nsRP may experience scarring of the prostatic bed leading to fibrosis at the site of the neurovascular bundles. This consequently may lead to an increased rate of ED. In terms of oncologic safety, these patients may have a more favorable outcome after adjuvant radiotherapy, which leads to bias when compared to patients without any additional treatment. Therefore, it was crucial to employ these exclusion/inclusion criteria to avoid any confounding factors.

Our study demonstrated that an anatomically defined ePLND did not affect continence and EF recovery in comparison with lPLND. Continence and spontaneous EF recovery rates at 12 months were 89.7 versus 93.4 % and 40.4 versus 47.5 %, in ePLND and lPLND, respectively (all $p > 0.05$). These results were confirmed at univariate and multivariate analyses after accounting for clinical, pathological and functional variables. Only patient age at surgery, preoperative EF and pathological tumor stage were independent predictors of EF recovery, whereas no association was detected regarding continence recovery. Similar results in regard to EF and continence recovery after RP have recently been reported by various authors [6, 11].

During nsRP, potential neural damages can occur at the level of the pelvic plexus. The pelvic plexus gives origin



pT2	BCR lPLND	0	0	0	0	0	0	0	0
	BCR ePLND	0	5	6	7	7	8	9	9
	At risk lPLND	160	160	158	108	69	58	43	25
	At risk ePLND	200	195	194	193	154	115	85	38
pT3	BCR lPLND	0	2	2	2	2	2	2	2
	BCR ePLND	0	4	4	5	7	9	9	9
	At risk lPLND	38	36	35	19	10	8	5	4
	At risk ePLND	60	56	55	54	30	14	7	0

Fig. 3 Kaplan–Meier curve of biochemical recurrence-free survival in patients with extended (intermediate- and high-risk PCa) and limited (low-risk PCa according to preoperative classification by D'Amico) pelvic lymph node dissection, subdivided into pT2 and pT3 subgroups. Inset table presents 7-year biochemical recurrence-free survival (7-year BCR) and p values of the log-rank test. $N = 2$ patients with pT4 PCa not included. *PSA* prostate-specific antigen, *lPLND* limited pelvic lymph node dissection, *ePLND* extended pelvic lymph node dissection

Table 4 Trifecta outcomes in patients with extended and limited pelvic lymph node dissection, listed according to years after bilateral nerve-sparing radical prostatectomy (extended PLND: intermediate- and high-risk prostate cancer; limited PLND: low-risk prostate cancer according to D'Amico)

Time to trifecta (years)	ePLND cumulative (%)	lPLND cumulative (%)
1	38.2	45.5
2	44.1	47.5
3	44.9	47.5
7	47.1	47.5

ePLND extended pelvic lymph node dissection, *lPLND* limited pelvic lymph node dissection

mainly to fibers deputed to the innervation of the cavernous bodies, therefore being responsible for EF. Importantly, the pelvic plexus lies in close proximity to internal iliac vessels and lymph nodes. Therefore, pelvic plexus fibers might be potentially injured during ePLND, especially when the internal iliac area is dissected [6]. Despite this potential damage, our study did not demonstrate a negative association between ePLND and EF recovery. Our results are in line with Gandaglia et al. [6]. In this study, EF recovery after BNSRP was compared between ePLND versus no PLND. EF recovery rates were 49.7 versus 46.6 % at 2 years, in these groups, respectively ($p = 0.33$). Like in our study, the authors also showed that patient age and preoperative EF are major predictors of EF recovery. Unfortunately, continence outcomes were not reported. However, there are some differences compared to our study. The decision to perform ePLND or no PLND by Gandaglia et al. was left to the surgeon by intraoperative judgment, which represents subjective assessment and may lead to bias. Moreover, Gandaglia et al. included only low-risk

PCa. In our study, we included also intermediate- and high-risk PCa and showed that even in those groups who underwent ePLND there is no significant difference in EF and continence recovery compared to low-risk PCa (lPLND). Although discussed controversially in the literature, we performed lPLND in low-risk PCa, mainly to provide a minimal lymph node staging. However, practices with regard to PLND in PCa are inconsistent between existing guidelines and institutions, and therefore, no consensus exists about the optimal extent of PLND [11]. Mean number of removed lymph nodes in ePLND, which represents an indicator for adequate lymph node dissection, was 20.3 by Gandaglia et al., which is similar to our results (mean number of lymph nodes: 20.4). According to a recent study by Sagalovich et al., high-risk PCa patients should undergo ePLND with at least 13 lymph nodes removed for accurate staging [11]. Sagalovich et al. also showed that ePLND with lymph node yield of ≥20 is associated with worse potency outcomes, which is in contrast to Gandaglia et al. and our study. However, results by Sagalovich et al. have to be regarded with caution. First, results were reported after median of 6 months. EF after RP can take a longer time period to recover; thus, the follow-up is inadequate. Second, the number of patients with high-risk PCa who were evaluated in regard to potency outcomes was small, with only 29 patients included. Therefore, no conclusions can be made regarding EF recovery after ePLND in this study. Another important aspect is the different assessment of EF. Preoperatively, the IIEF-5 score was used. However, postoperative assessment of EF consisted only of questions 2 and 3 of the IIEF-5 questionnaire. This is in contrast to Gandaglia et al. and our study, where the IIEF-EF and IIEF-5, respectively, were used preoperatively and postoperatively, which gives more detailed information regarding EF. Besides potency outcomes, continence recovery was not significantly different between the two groups in this study. Continence recovery rates were up to 92.8 %, irrespective of risk group and extent of PLND [11]. This is also reflected by our study. Thus, according to Sagalovich et al. and our study, the extent of PLND does not have any influence in regard to continence recovery after BNSRP. This is important information as there is lack of data regarding this aspect in the literature. Overall, our study supports the use of ePLND in intermediate- and high-risk PCa without negatively affecting functional outcomes.

Regarding oncological outcomes, we did find a significantly different 7-year BCR-free survival between the lPLND and ePLND groups only in patients with pT2 PCa. This difference might be explained in part by the fact that patients with lPLND (low-risk PCa) display more favorable parameters in terms of PSA/Gleason score with decreased likelihood of BCR in comparison with intermediate- and high-risk PCa (ePLND) [16–19]. In this regard, it should be emphasized that most of the results of our study did not show a significant difference between the ePLND and lPLND groups. Moreover, the statistical difference observed between those two groups in pT2 PCa in terms of BCR-free survival would have marginal clinical implications. However, there was no such significant difference in regard to BCR-free survival between the two groups for pT3 disease. The trifecta rate that displays patients who achieve continence, potency and recurrence freedom is often used to assess outcomes after BNSRP. Our study represents the first report of trifecta outcomes comparing the extent of PLND (ePLND vs. lPLND) in patients undergoing BNSRP. In our study, trifecta rates were 47.5 and 44.1 % in lPLND and ePLND, respectively, at 2 years ($p = 0.451$). These trifecta results reflect that by means of an adequate PLND in patients with intermediate- and high-risk PCa we can achieve similar oncological and functional outcomes after BNSRP compared to patients with low-risk PCa. Our results are close to those of Novara et al., who reported a trifecta rate of 57 % after robot-assisted RP, at 12 months [20]. However, looking only at high-risk PCa, Lavery et al. [21] found a trifecta rate of 23 %. According to a recent review, trifecta rates after nsRP range from 20 to 76 % [2]. This wide range in the literature might be explained by different tools used to assess continence and EF [2].

There are some limitations that should be considered. First, all patients were treated with BNSRP, which has been reported as major predictor of EF recovery [22, 23]. Thus, our results are not applicable to patients treated without a ns approach. Second, the study population could have been larger. However, to have clear data regarding the effect of PLND on functional outcomes, it was necessary to exclude confounding factors, such as neoadjuvant/adjuvant treatment. Moreover, to provide realistic and clear results regarding EF and to report spontaneous EF recovery rates, patients using PDE-5i were excluded. However, on the other hand, these rigorous exclusion/inclusion criteria represent a major strength of our study. Another limitation is that pad usage as definition of continence is not validated. Direct assessment by validated questionnaires would have been better. However, pad testing provides an objective form of incontinence assessment [24–26]. An important issue that should also be addressed is that the present cohort is enriched of patients with low- and intermediate-risk PCa, with only few patients with high-risk disease, which are most likely patients undergoing an ePLND during RP. The present study represents an open RP series. However, providing that the lymph node dissection follows the same anatomic landmarks as described above, results of our study can also be extrapolated to patients undergoing laparoscopic or robot-assisted RP. The present study is further limited by its retrospective design. In future attempts to further investigate the effect of PLND during nsRP on functional and oncological outcomes, a preferably multicenter validation may be necessary.

Conclusions

ePLND is not associated with increased risk of postoperative incontinence or ED after BNSRP. ePLND can safely be performed when oncologically indicated without compromising continence and EF recovery rates. Only patient age at surgery, preoperative EF and pathological tumor stage represent predictors of postoperative EF recovery.

Authors' contribution G. Hatzichristodoulou involved in project development, data collection and management and data analysis and wrote the manuscript. S. Wagenpfeil and G. Wagenpfeil involved in data analysis. T. Maurer, T. Horn, K. Herkommer and M. Hegemann involved in data collection. J. Gschwend and H. Kübler edited the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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