Technical Aspects of Pelvic Lymph Node Dissection Impact Nodal Yield

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Abstract

Introduction: *Pelvic lymph node dissection (PLND) is a diagnostic/therapeutic surgery performed for gynecologic and urologic malignancy. Henceforth, we examined the differences in PLND techniques of gynecologic oncologists (GO) and urologists at a single health care system.*

Methods: *The anatomic sites, amounts, and number of lymph nodes retrieved were analyzed retrospectively for PLND performed for bladder or uterine cancer between January 2009 and December 2013.*

Results: *Information on 370 patients who underwent PLND was included. The median number of lymph nodes obtained was 27 (IQR: 18-35). Factors such as age and BMI had no impact on lymph node counts. GO's removed greater (p<0.0001) total lymph nodes (median 30; IQR: 24-37) than urologists (median: 15; IQR: 7-21), likely related to the larger number of packets (8 vs. 3) and volume of tissue (145.3 vs. 85.2 cm^3) collected. In multivariable analysis, significant predictors of node counts were volume of tissue (+0.82 per $30cm^3$, p<0.0001), number of packets (+2.08 per additional packet, p<0.0001), and minimally-invasive surgery (MIS) approach (+2.90, p<0.0001), and surgical specialty (+3.42 for GO, p<0.0001). The predictors of detection of positive LNs were grade (OR: 2.93, p=0.006), age (p=0.0014), and BMI (p=0.0247).*

Conclusions: *The disparity in lymph node counts during PLND appears to be attributed to several factors, including increased volume of tissue collected, more extended template, and higher number of packets. Use of an MIS approach did not compromise nodal yield or detection of positive nodes. Technical aspects of PLND greatly affect LN counts, but may not impact staging.*

Keywords: *bladder cancer, endometrial cancer, lymphadenectomy, lymph node dissection.*

INTRODUCTION

Genitourinary cancers are steadily becoming more common in the United States, with increases of slightly over five percent since 2010. [1, 2] In order to properly stage and cytoreduce the associated tumors, pelvic lymph node dissection (PLND) is commonly performed. The tissue packets are then dissected by pathologists to give the number and metastatic state of the lymph nodes (LN).[3] The presence or absence of positive LNs provides staging information, and can inform recommendations regarding adjuvant therapy. [4, 5]

PLND can be performed during open, laparoscopic, and robot-assisted surgical techniques.[3] For each type of malignancy, the templates used during PLND differ somewhat, including the number and location

of LNs removed.[6, 7]   For example, the number of LNs removed and template have been shown to correlate with survival after radical cystectomy for bladder cancer.[8, 9]   The risk level of endometrial cancer is also an important factor in making decisions regarding PLND extent.[7, 10]   While it is usually beneficial for patients with high-risk endometrial cancer to undergo PLND to accomplish accurate staging, lymphadenectomy may increase morbidity and cost of care in low-risk cancer without a clear benefit. [11, 12]

Underlying comorbidities, as well as oncologic risk, may also play a role in endometrial cancer patient outcomes in response to PLND. [7, 13]

Prior research at our institution compared PLND performed by 3 GO's according to an established protocol, finding that LN counts were not associated with the surgeon, prosector, or pathologist.[14] Herein, we compare LN counts and technique during PLND performed subsequent to this work with the ability to examine additional potential cofactors, such as surgical specialty and MIS techniques.

MATERIALS AND METHODS

Patients and Study Design

Institutional review board approval was received for the use of data maintained within our institutional tumor registry. A cohort of patients was identified as having undergone PLND and/or by tumor registry for urothelial or endometrial cancer during the time period from 1/1/2009 to 12/31/2013, which immediately follows the cohort examined previously and has >5 year median clinical follow-up.[14] All patients who were identified by this method had their electronic medical record reviewed to determine if they met inclusion criteria for the study. Inclusion criteria included adult patients (18 years or older at time of surgery) who had undergone PLND during the specified time period for bladder or endometrial malignancy. Exclusion criteria included PLND for other pelvic malignancies (e.g., ovarian, cervical, prostate, penile, etc.) as the template and extent of PLND may differ for these malignancies, history of prior PLND, history of additional primary nodal pathology or synchronous primary tumor (other than prostate cancer for patients with bladder cancer), and absence of a pathology report in the electronic medical record. Of 901 patient records reviewed, 370 met inclusion criteria and were included in the study, including 4 pure laparoscopic PLND and 59 robot-assisted PLND analyzed together (MIS approach) and 307 open PLND. Common reasons for exclusion included: malignancy not meeting entry criteria, no PLND performed, synchronous cancer, and duplicate patient record.

Endpoints and Assessments

The primary endpoint of this retrospective study was the number of LNs obtained during PLND. Secondary outcomes included the number of positive LNs, volume of LN tissue collected, number of LN packets, and anatomic location of positive LNs.   Anatomic locations were recorded based on the location stated by the surgeon in the operative report and were divided into three levels. Level I included all nodes that are anatomically located within the pelvis, including external iliac, obturator, and internal iliac LNs. Common iliac and presacral LNs were defined as Level II; para-aortic and paracaval LNs were defined as Level III nodes.

Statistical Analysis

Either Wilcoxon Rank Sum Test (2 groups) or a Kruskal-Wallis test (2 or more groups) were used with Dunn's test as the pairwise comparison where appropriate to compare differences in LN count and LN packet count. Univariate models were run using various co-factors to see if they were associated with LN count and a multivariate model was created. All statistical analyses were generated using SAS/JMP software Version 9.4/13.

RESULTS

Patients

Demographic and clinical information on the patients included in the study is found in Table 1. This cohort includes 263 PLNDs performed by 5 GO's (72.6%) and 107 by 13 urologists (27.4%). Median patient age was 64 (IQR: 57-72) years and 78.1% of patients were female. A majority of cases were performed via an open approach (83.0%), while MIS techniques made up the remaining cases. Overall, just over half (51.3%) of the patients had low grade cancer. Median overall LN count was 27 (IQR: 18-35), median overall volume of LN tissue was 4.20 per 30 cm^3 (IQR: 2.73-6.64), and the median number of packets was 8 (IQR: 4-8). LN metastases were identified in 19.2% of cases, including 17.9% of GO and 22.4% of urologic surgeries.

Table 1. *Demographic and clinical data regarding 370 patients undergoing pelvic lymph node dissection for bladder or uterine malignancy.*

	% (N) / Median (IQR)		% (N) / Median (IQR)
Median patient age, years (IQR)	64 (57-72)	*Female gender*	79.1% (306)
Race		*Smoking status*	
Caucasian	91.3% (338)	*Never*	61.5% (226)
African-American	2.7% (10)	*Former*	26.0% (96)
Hispanic	2.7% (10)	*Current*	13.0% (48)
Other/Unknown	3. % (12)		
Comorbidity count		*Year of surgery*	
% with No Comorbidities	14.3% (53)	*2009*	23.8% (88)
% with 1 Comorbidity	26.8% (99)	*2010*	23.8% (88)
% with >1 Comorbidity	58.9% (218)	*2011*	19.9% (74)
		2012	12.7% (47)
		2013	19.7% (73)
Median BMI, kg/m² (IQR)	31.7 (26.3-37.9)	*Surgical Specialty*	
<25.0	18.4% (68)	Gynecologic Oncology	71.1% (263)
25-29.9	26.6% (99)	Urology	28.9% (107)
30-34.9	21.3% (79)	General Urology	59.8% (64)
35-39.9	15.4% (57)	Urologic Oncology	40.2% (43)
≥40	18.1% (67)		
Primary Malignancy/ Pathological Risk Group	**28.9% (107)**	*Surgical approach*	
Bladder	32.7% (35)	Open	83.0% (307)
≤pT1	29.0% (31)	MIS	17.0% (63)
pT2	23.4% (25)		
pT3	14.9% (16)		
pT4	**71.1% (263)**		
Endometrial * Low	55.9% (147)		
Intermediate	6.5% (17)		
Intermediate-High	3.8% (10)		
High	33.8% (89)		
Grade **		IQR: interquartile range; LN: lymph node	
Low	51.3% (190)		
High	48.7% (180)		
Median LN packets (IQR)	8 (4-8)		
Median LN Packet Volume (IQR)	126.0 (81.8-199.2)		
Median LN count (IQR)	27 (18-35)		
Median positive LN count (IQR)	3 (1-6)		
Proportion with positive LN's	19.2% (71)		

* Endometrial Cancer Risk Groups (assigned per ESMO-ESGO-ESTRO guidelines[7]): **Low**: stage I endometrioid cancer (EC), G1 or G2, with superficial myometrial invasion <50%, lymphovascular space invasion (LVSI) negative; **Intermediate**: stage I EC, G1 or G2, with deep myometrial invasion >50%, LVSI negative; **High-intermediate**: stage I, G3, with superficial myometrial invasion <50%, any LVSI; OR stage I EC, G1 or G2, with LVSI unequivocally positive, any depth of invasion; **High**: stage I, G3, with deep myometrial invasion >50%, any LVSI; OR stage II; OR stage III with no residual disease; OR non-EC (serous, clear cell or undifferentiated carcinoma or carcinosarcoma)

** Low Grade: low-grade urothelial carcinoma OR FIGO 1-2 endometrial cancer; High Grade: high grade urothelial carcinoma OR FIGO 3 endometrial carcinoma

Overall Lymph Node Counts

A number of factors were examined to determine if they predicted LN count and packet number (Table 2). Most of the examined factors were associated with LN count, and all factors were associated with number of packets except year of surgery. For example, surgical specialty (GO or urology) was demonstrated to be a significant predictor of LN count. Median LN count for cases performed by GO's was 30 (IQR: 24-37), compared with 15 (IQR: 7-21) for urologists (p<0.0001). Among urologists, subspecialty training in urologic oncology was associated with a higher LN count: median LN count was 22 (IQR: 15-29) for urologic oncologists (UO's) and 9 (IQR: 5-17) for general urologists (p <0.0001). LN count was significantly higher for GO's than UO's (p= <0.0001), and LN counts with general urologists were significantly lower than both GO and UO (respectively (p<0.001). Low grade cancer was associated with significantly higher median LN (30, IQR: 24-36) count than high grade cancer (21, IQR:10-31). The techniques used for robotic PLND by GO and UO are demonstrated (Videos 1 and 2). [7]

Table 2. *Predictors of lymph node count and lymph node packet count*

	LN Count			LN Packet Count		
	Median (IQR)	P value	Results*	Median (IQR)	P value	Results*
Age		<0.0001			<0.0001	
<63[1,*]	30 (23-36)		2	8 (6-8)		2
≥63[2]	24 (14-34)		1	7 (3-8)		1
BMI (kg/m²)		<0.0001			<0.0001	
<25.0[1]	24 (13-31.5)		3,4,5	6 (3-8)		3,4,5
25-29.9[2]	22 (10-31)		3,4,5	5 (2-8)		3,4,5
30-34.9[3]	29 (23-34)		1,2	8 (5-8)		1,2
35-39.9[4]	30 (22.5-36)		1,2	8 (6-8)		1,2
≥40[5]	32 (23-38)		1,2	8 (7-8)		1,2
Race Caucasian		0.82			0.83	
African American	27 (18-35)		-	8 (4-8)		-
Other	27 (21-37.5)		-	7.5 (5.5-8)		-
	29 (15-34)		-	8 (4-8)		-
Smoking Status		0.0002			<0.0001	
Non-smoker[1]	29 (23-36)		2,3	8 (6-8)		2,3
Former smoker[2]	23 (13-34)		1	5 (2-8)		1
Current Smoker[3]	23.5 (13-31)		1	5.5 (3-8)		1
Surgical Specialty		<0.0001			<0.0001	
Gynecologic oncology[1]	30 (24-37)		2,3,4	8 (7-8)		2,3,4
Urology[2]	15 (7-21)		1	3 (2-5)		1
General Urology[3]	9 (5-17)		1,4	2 (2-3)		1,4
Urologic Oncology[4]	22 (15-29)		1,3	5 (4-7)		1,3
Surgical Approach		0.98			<0.0001	
Open[1]	27 (18-35)		-	8 (5-8)		2
MIS[2]	26 (18-34)		-	4 (4-6)		1
Year of Surgery		<0.0002			0.033	
2009[1]	32 (22-40)		3,4	8 (6-8)		4,5
2010[2]	29 (19-37)		3,4	8 (6-8)		4,5
2011[3]	24 (15-29)		1,2,5	7 (4-8)		-
2012[4]	24 (14-30)		1,2	7 (3-8)		1,2
2013[5]	27 (22-34)		3	8 (4-8)		1,2

Primary Malignancy		<0.0001			<0.0001	
Bladder[1]	15 (7-22)		*2*	3 (2-5)		*2*
Endometrial[2]	30 (24-37)		*1*	8 (7-8)		*1*
Grade		<0.0001			<0.0001	
Low[1]	30 (24-36)		*2*	8 (7-8)		*2*
High[2]	21 (10-31)		*1*	5 (2-8)		*1*
Number of Packets		<0.0001				
1-2[1]	6.5 (3-14)		*2,3*			
3-7[2]	26 (16.5-36)		*1,3*			
≥8[3]	30 (24.5-36)		*1,2*			

In the first column, the superscript numbers indicate each subgroup's number.

In the results columns (*), the numbers indicate the groups with statistically significant differences compared to the listed subgroup.

In order to further understand the differences that exist between GO and urologist techniques for PLND, and the association of these factors with LN count, univariable and multivariable analyses were performed (Table 3). In univariable models all factors other than race, comorbidity, and surgical approach were associated with LN count. In a multivariable model, higher volume of LN tissue (0.82 per 30cm³), more LN packets (2.08 per additional packet), and MIS approach (2.90 more) were strongly associated (each p<0.0001) with total LN count. After accounting for these factors, grade, smoking status, and BMI were no longer predictors of LN count. The strong associations of number of packets and volume of tissue collected with total LN count are further evident in Figures 1 and 2. The median LN count was 6, 26, and 30 when 1-2, 3-7, or 8 or more packets were collected (p<0.0001). Pair-wise testing revealed significant differences between each of the three groups.

Table 3. *Univariable and multivariable analysis of factors associated with lymph node count.*

	Univariable Model		Multivariable Model	
	Estimate (95% CI)	*P-Value*	*Estimate (95% CI)*	*P-Value*
Age, years	-0.24 (-0.35, -0.12)	<0.0001	-0.03 (-0.12, 0.08)	0.60
Caucasian race (vs. all others)	0.60 (-1.92, 2.73)	0.73	0.62 (-1.05, 2.28)	0.50
Multiple comorbidity (vs. 0-1)	-0.48 (-1.80, 0.85)	0.48	-0.41 (-1.44, 0.63)	0.44
Non-smoker	3.94 (2.13, 5.76)	<0.0001	0.18 (-1.30, 1.65)	0.81
BMI	0.37 (0.24, 0.51)	<0.0001	-0.03 (-0.17, 0.10)	0.25
Year of surgery	-1.18 (-2.08, -0.28)	0.0106	-0.91 (-1.62, -0.20)	0.0122
Gynecologic oncology (vs. urology)	7.62 (6.40, 8.83)	<0.0001	3.42 (1.77, 5.07)	<0.0001
Open (vs. MIS)	-0.03 (-1.77, 1.71)	0.98	-2.90 (-4.22 -1.43)	<0.0001
Number of LN packets	3.10 (2.67, 3.53)	<0.0001	2.08 (1.56, 2.61)	<0.0001
Volume of LN tissue, per 30 cm³	1.38 (1.07, 1.69)	<0.0001	0.82 (0.54, 1.10)	<0.0001
High Grade (vs. Low)	-4.56 (-5.78, -3.33)	<0.0001	-0.005 (-1.34, 1.33)	0.99
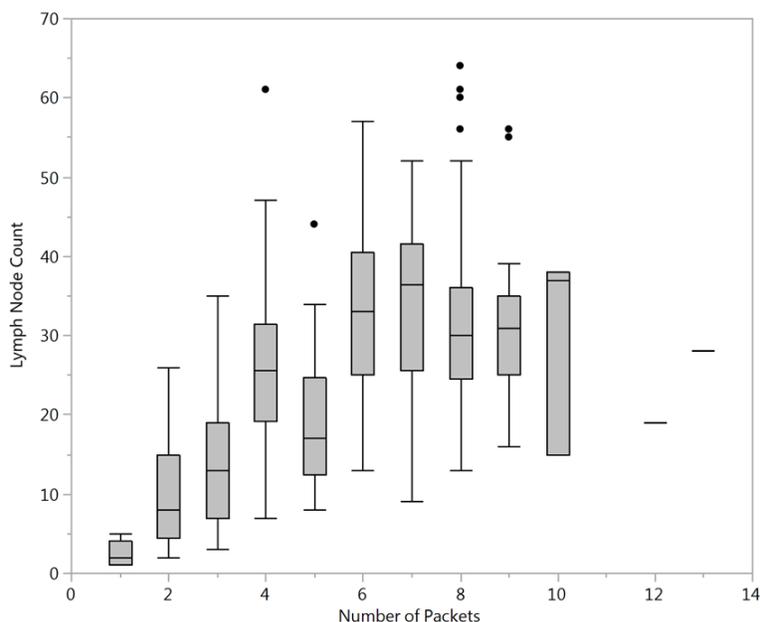
Figure 1. *Lymph node count according to number of LN packets*
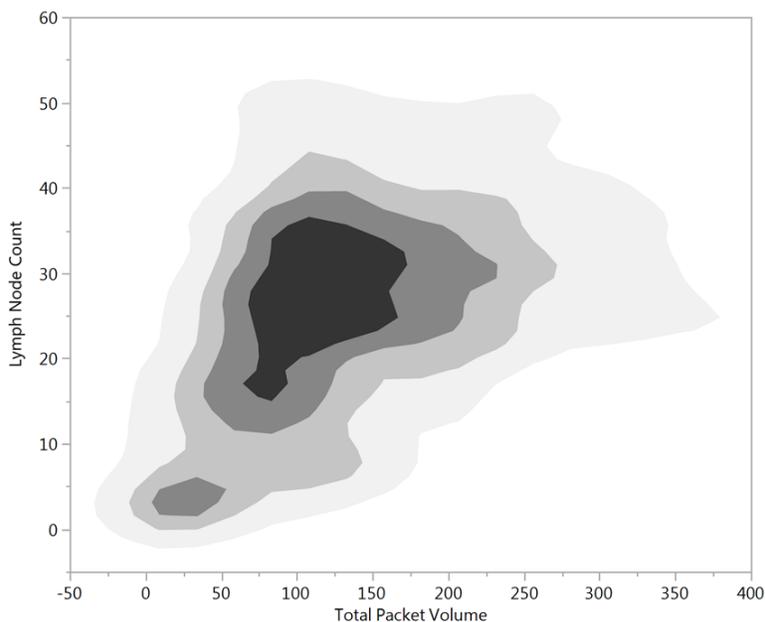
Figure 2. *Lymph node count according to total volume of LN packets*

Lymph Node Counts by Level

Further analysis of the surgical technique used for PLND by GO and urologists identified other significant differences. First, the number of LN packets collected by GOs was significantly higher (p<0.0001) with more than double the LN packets (median: 8; IQR: 7-8) compared with urologists (median: 3; IQR: 2-5). In the majority of cases, urologists collected only Level I LNs, while GOs collected Level I, II, and III LNs (Table 4). Even when examining only Level I LNs; however, LN counts were higher for GOs (median: 18; IQR: 14-23) than for urologists (median: 12; IQR: 6-17). Interestingly, the relative increases in LN counts level-by-level were roughly similar to the relative volume of tissue collected from each level. For Level I, GOs collected 45% more tissue (median: 117.2 vs. 79.8

cm^3, Table 5), resulting in 50% more LNs (median: 18 vs. 12). For Level II, tissue volume (median: 15.0 vs. 17.5 cm^3) and LN count (median: 6 vs. 5) were similar for GO and urologists, respectively. For Level III, GOs collected more tissue (median: 16.4 vs. 8.3 cm^3) and harvested more LNs (median: 6 vs. 4).

Table 4. *Lymph node count level by level during pelvic lymph node dissection performed by gynecologic oncology and urology.*

	Cases with LN Collected (% of cases with node collected)	Cases with Positive LN Collected (Positive % when collected)	Median LN Count when Level Taken (IQR)
Gynecologic Oncology	263	47 (17.9%)	
Level 1	257 (97.7%)	40 (15.6%)	18 (14-23)
Level 2	231 (87.8%)	17 (7.4%)	6 (4-8)
Level 3	255 (97.0%)	26 (10.2%)	6 (4-8)
Urology	107	24 (22.4%)	
Level 1	106 (99.0%)	24 (22.6%)	12 (6-17)
Level 2	51 (47.7%)	6 (11.8%)	5 (2-7)
Level 3	11 (10.3%)	2 (18.2%)	4 (1-6)

Table 5. *LN count and aggregate size by level and side during pelvic lymph node dissection performed by gynecologic oncology and urology when patients had lymph nodes collected from each level.*

	Gynecologic Oncology			Urology		
Lymph Node Count Median (IQR)	Right	Left	Total	Right	Left	Total
Level I - Pelvic, external iliac, obturator, and internal iliac	10 (7-13)	9 (6-12)	18 (14-23)	5 (3-9)	5 (2.8-8.3)	12 (6-17)
Level II – Common Iliac and pre sacral	2 (1-3)	3 (2-4)	6 (4-8)	2 (0-4)	1 (0-3)	5 (2-7)
Level III – Paracaval or Paraaortic	3 (2-4)	3 (2-5)	6 (4-8)	3 (1-4)	1 (0-2)	4 (1-6)
Total	30 (24-37)			15 (7-22)		
Lymph Node Packet Volume, cm^3 Median (IQR)	Right	Left	Total	Right	Left	Total
Level I – Pelvic, external iliac, obturator, and internal iliac	61.1 (35.4-100.1)	57.4 (35.6-80.6)	117.2 (74.5-180.1)	40 (24.9-73.4)	33.4 (16.9-53.5)	79.8 (45.2-115.4)
Level II – Common Iliac and presacral	6.2 (4.1-11.7)	7.3 (4.4-13.2)	15.0 (10.0-23.1)	8.6 (4.3-13.5)	6.2 (2.2-11.2)	17.5 (9.8-24.8)
Level III – Paracaval or Paraaortic	7.6 (5.1-12.0)	7.3 (5.6-12.4)	16.4 (11.1-23.1)	8.3 (2.5-14.9)	2.8 (1.3-4.4)	8.3 (6.3-16.8)
Total	145.3 (98.3-220.9)			85.2 (48.4-126)		

Positive Lymph Nodes

In order to determine which factors impact the detection of metastatic LNs, univariable and multivariable analyses were performed (Table 6). In univariable models that included LN count, extent of PLND (by level), and all the factors analyzed for ability to predict LN count (Table 3), only age (OR: 1.06, p<0.0001), LN count (OR: 0.98, p=0.018), and grade (OR: 2.86, p=0.0002) had any statistically significant

impact on the detection of positive LNs. Similarly, in a multivariable model, with all of those factors included, grade (OR: 2.93, p=0.006), age (OR: 1.06, p=0.0014), and BMI (OR: 1.05, p=0.0247) were the statistically-significant variables. These models all had low R^2 values (data not shown), indicating that there is a high degree of randomness with respect to the relative ability of these variables to predict detection of LN metastases.

Table 6. *Univariable and multivariable analysis of factors associated with detection of metastatic pelvic LN.*

	Univariable Model		Multivariable Model	
	OR (95% CI)	*P-Value*	*OR (95% CI)*	*P-Value*
Age, years	1.06 (1.03,1.09)	<0.0001	1.06 (1.02, 1.09)	0.0014
Caucasian race (vs. all others)	2.43 (0.72, 8.23)	0.15	2.73 (0.73, 10.30)	0.14
Multiple comorbidity (vs. 0-1)	1.17 (0.69, 1.99)	0.56	0.92 (0.50, 1.68)	0.78
Non-smoker	1.17 (0.64, 2.14)	0.977	1.70 (0.57, 5.13)	0.25
BMI	1.0 (0.97, 1.03)	0.88	1.05 (1.01, 1.09)	0.0247
Year of surgery	0.93 (0.90, 1.29)	0.44	0.95 (0.76, 1.19)	0.66
Gynecologic oncology (vs. urology)	0.75 (0.44, 1.32)	0.32	2.99 (0.75, 11.87)	0.12
Open (vs. MIS)	1.77 (0.80, 3.92)	0.13	1.19 (0.42, 3.42)	0.74
LN Count	0.98 (0.96, 1.03)	0.018	0.97 (0.94, 1.01)	0.13
Number of LN packets	0.96 (0.86, 1.05)	0.40	1.09 (0.85, 1.41)	0.48
Volume of LN tissue, per 30 cm^3	0.96 (0.89, 1.04)	0.28	0.95 (0.85, 1.06)	0.34
Levels taken (I only vs. I,II,III)	1.55 (0.79, 3.03)	0.099	1.80 (0.24, 13.33)	0.99
High Grade (vs. Low)	2.86 (1.64, 4.96)	0.0002	2.93 (1.36, 6.30)	0.006

DISCUSSION

The extensiveness of PLND plays a role in the staging of cancer and prevention of relapse.[15] An insufficient PLND may result in inaccurate staging, while a thorough dissection benefits both N0 and N1 cohorts (the so-called 'Will Rogers effect').[15] In bladder cancer, an extended PLND has been shown to be more likely to detect metastatic LN than a limited PLND[16-18] In SWOG 8710 several aspects of bladder cancer surgery, including performance of PLND and LN counts were associated with cancer-specific survival.[9, 19] Additional recent reports also indicate extended PLND in conjunction with radical cystectomy may confer additional survival benefit. [20]

We examined multiple factors in order to determine their effect on LN count during PLND. These included age, BMI, smoking status, race, grade, type of provider that conducted the surgery, and surgical technique (open vs. MIS). At univariable analysis, the type of

surgery (MIS vs. open) did not affect LN counts, but surgical specialty did, with GO's obtaining more LN than urologists. Multivariable analyses indicated that the volume of LN tissue, the number of LN packets collected, and use of MIS were the most reliable predictors of LN count along with surgical specialty.

Upon identification of these results, practitioners from the sections of urology and GO met to discuss reasons that pelvic LN counts were higher for endometrial malignancy compared to bladder malignancy. Several years prior, the GO's embraced a template for PLND which included four anatomic sites from which to harvest LN (external iliac, obturator, common Iliac, and para-aortic) and; therefore, a majority of the endometrial cancer surgeries yielded these eight LN packets. In comparison, the urology section had had no such template and produced LN counts typical of a standard (or 'limited') PLND.[21] During the years under study, GO's routinely obtained aortic LNs, while many urologists truncated PLND at the level of the

common iliac artery bifurcation. An ongoing SWOG trial (S1011) is investigating whether performing an extended (Level I and II LNs) vs. a standard (Level I only) PLND will impact survival in bladder cancer patients and has an estimated completion date of 2022. In the endometrial cancer literature, recent work suggests routine aortic LN dissection may not be necessary.[22] In addition, sentinel LN assessment as a strategy to reduce the morbidity of PLND in early-stage endometrial cancer is also undergoing further investigation and may replace pelvic and aortic lymphadenectomy.[23, 24] So, while the extent of PLND is a matter of investigation for each of these diseases, our data indicate that the template of dissection and amount of tissue removed are strong predictors of LN count.

While the template is an important factor in the difference in LN counts, it does not fully explain the disparity given when only considering Level I nodes, GOs still had a higher median count than urologists (Table 4). Additionally, when adjusting for patient and surgical factors

GOs still collected significantly more lymph nodes per dissection than urologists (Table 3). One consideration is that the patient's primary malignancy influences the recommendation regarding the extensiveness of PLND. For example, the intention during cystectomy for invasive bladder cancer and during a hysterectomy for most endometrial cancer is to perform a complete pelvic lymphadenectomy, whereas the intent in surgery for other malignancies may be pelvic LN sampling. Because of these reasons, we limited the focus of the present work on these two malignancies. Our data suggest that GOs and UOs performed PLND with this intent, often using an 8-packet template, which may encourage more thorough LN dissection. It is possible that PLND by other urologists may result in lesser LN counts because the surgery is performed as a staging procedure, rather than being considered to have potential therapeutic impact.[6, 9, 19, 25-27] The volume of tissue collected by GOs vs. urologists indicates that the thoroughness of the dissection varied (Table 5). The amount of tissue collected was a very strong predictor of LN counts and likely reflected dissection in regions beyond the obturator fossa, including internal iliac, external iliac, and fossa of Marcille (Video 2). [7, 28, 29]

With regard to detection of metastatic lymph nodes, our findings indicate that the collection of additional LN's, LN packets, collection of multiple levels of LN's, or LN packet volume (Table 6). Instead, the detection of metastatic LN's depends more on patient-specific factors such as cancer grade and age, indicating that a personalized approach to the extent of dissection may be possible with the necessary information.

This cohort analysis suffers from the limitations of any retrospective review including many biases; however, we tried to limit these biases by including all surgeries that met criteria and by doing a thorough chart review to include as many co-factors as possible. There may be other co-variables that were not considered or that are unknown that could impact results. There were more PLNDs performed by GOs than by UOs and general urologists, and many PLND performed by these surgeons for other malignancies (such as prostate cancer) were not included. Given that surgical volume has been shown to impact surgical outcomes in pelvic malignancy,[30] this could have impacted our results. Thus, our data may not be applicable at other institutions with differences in surgical volumes and ratios of surgeries performed.

Conclusions

The findings from this study highlight that surgical technique impacts LN count during PLND. Increasing the volume of tissue collected and the number of packets retrieved from an extended template resulted in increasing LN counts, but no greater detection of LN metastases. These refinements in surgical technique could be transferred for quality improvement if all surgeons involved are approaching PLND with the same intent. Specifically, a prospective study in which patients are enrolled prior to PLND and in which the surgeon documents the template and intent before as well as immediately afterward (since the original intent might change during the operation) may allow a more accurate assessment of the etiology of the observed differences: technique or intent. Additional studies of PLND performed at other institutions would be important to validate our findings. Regardless, we anticipate the results of the prospective studies evaluating the template of PLND most appropriate for bladder and endometrial cancers and hope our study aids surgeons in understanding the impact of their technique on the LN count obtained.

Author's Contributions

K Walhof: Protocol/Project Development, Data Collection, Manuscript writing

A Drolet: Protocol/Project Development, Data Collection, Manuscript writing

B Doss: Data analysis, Manuscript editing

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COMPLIANCE WITH ETHICAL STANDARDS

Ethical Approval

All procedures performed in studies 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.

For this type of study formal consent is not required. This article does not contain any studies with animals performed by any of the auithors.

Informed Consent

Based on the retrospective design of the study and minimal risk to the subjects, a waiver of informed consent has been requested for the study patients and was approved by the Spectrum Health Institutional Review Board.

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