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Trends in Sentinel Lymph Node Mapping and Adjuvant Therapy in Endometrial Carcinoma

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Abstract

We analyzed 54,039 women with uterine cancer in the National Cancer Database from 2013–2014 including 38,453 (71.2%) who underwent lymphadenectomy, 1929 (3.6%) who underwent sentinel lymph node (SLN) mapping, and 13,657 (25.3%) who did not undergo nodal assessment. SLN mapping increased from 2.8% in 2013 to 4.3% in 2014 ($P<0.001$). Patients treated in 2014 and those at community centers were more likely to undergo SLN biopsy, while women with advanced-stage disease, sarcomas, and grade 3 tumors were less likely to undergo SLN mapping ($P<0.05$). There was no association between use of SLN biopsy and use of radiation (aRR=0.92; 95% CI, 0.82–1.05).

Keywords

Uterine cancer; endometrial cancer; sentinel lymph node; lymphadenectomy; hysterectomy

Introduction

Endometrial carcinoma is the most common gynecologic cancer in developed countries (1). The standard treatment for patients diagnosed with endometrial cancer is hysterectomy and bilateral salpingo-oophorectomy. The role of lymph node assessment remains controversial. While lymphadenectomy may provide prognostic information and help tailor adjuvant therapy, universal nodal assessment subjects a large number of women with uterine-confined

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disease to the procedure (2–4). Lymphadenectomy increases operative time and is associated with long-term sequelae such as lymphedema (5). Further, prospective trials have shown that lymphadenectomy is not associated with improved survival further calling into question the value of the procedure (6,7).

Sentinel lymph node (SLN) mapping has been proposed as an alternative to lymphadenectomy (8). SLN mapping relies on removal of a small number of lymph nodes that are the first drainage sites from a tumor and thus the most likely to harbor tumor cells (9,10). SLN mapping has the potential to reduce the morbidity of lymphadenectomy and has been extensively validated for a number of other solid tumors and is now in the standard of care in breast cancer, vulvar cancer, and melanoma (11–13).

Despite the potential benefits of SLN mapping, data describing the performance of the procedure in women with endometrial cancer is limited. We performed a population-based analysis of women with endometrial cancer to first determine the utilization and predictors of use of SLN mapping and second, to examine whether use of SLN mapping was associated with changes in the prescription of adjuvant therapy for women with early-stage tumors.

Methods

Data source

The National Cancer Database (NCDB) Participant Use Data File (PUF) was used for the analysis (14). The NCDB is a hospital-based registry developed by the American College of Surgeons and American Cancer Society. It contains data on all patients with malignant tumors from over 1,500 Commission on Cancer (CoC)-accredited hospitals, and represents more than 70% of newly diagnosed cancer cases across the United States. Incident tumor cases are collected by trained registrars and the data is examined and verified regularly to ensure quality. The data fields include patient demographics, tumor characteristics, treatment, survival, and hospital characteristics (14). The study was deemed exempt by the Columbia University Institutional Review Board.

Patient Selection

We identified women who had malignant uterine cancers diagnosed as their first or only cancer and confirmed with positive histology from 2013 to 2014. Women who had radiation before surgery or intraoperative radiation therapy were excluded. Women who did not have hysterectomy, or whose performance of nodal assessment was unknown were excluded. Women who had stage IV cancer or unknown stage were also excluded.

Patients were classified based on nodal assessment codes as having undergone sentinel lymph node (SLN) mapping, lymphadenectomy (LND), or no nodal assessment (no LND). Among patients who had a code for SLN mapping, additional non-sentinel nodes could be taken and discovered by the pathologist. We determined if they had a concurrent lymphadenectomy when review of the operative report confirmed that a regional lymph node dissection followed the SLN. In cases of failed SLN mapping, lymphadenectomy was usually performed and patients were classified as having SLN with concurrent lymphadenectomy. If no further regional lymph nodes were dissected, patients were

classified as having SLN mapping only. The number of nodes removed was recorded for each group of patients.

Demographic data included age (<50, 50–59, 60–69, 70–79, 80 years), race (white, black, Hispanic, other, unknown), year of diagnosis, and insurance status (private, Medicaid, Medicare, uninsured, other governmental/unknown). Income was measured by median household income in the patients' zip code and was classified as <\$38,000, \$38,000–\$47,999, \$48,000–\$62,999, \$63,000+, or unknown. Education was measured by the percentage of adults in a patient's zip code who did not graduate from high school, and classified as 21%, 13–20%, 7.0–12.9%, <7%, or unknown. Location was estimated by matching the patients' state and country FIPS code to rural-urban continuum codes from the United States Department of Agriculture Economic Research Service, and classified as metropolitan, urban, rural, and unknown. Comorbidity was measured using the Deyo adaptation of the Charlson's comorbidity score, and grouped as 0, 1, or 2 comorbid conditions(15).

Tumor stage was derived from the American Joint Committee on Cancer (AJCC) pathologic staging groups, and classified as IA, IB, I NOS, II, IIIA, IIIB, IIIC, and III NOS (not otherwise specified). Other tumor characteristics included histology (endometrioid, serous, clear cell, carcinosarcoma, sarcoma, and endometrial cancer not otherwise specified [NOS]/other) and grade (well, moderate, poorly, unknown). Hospital characteristics included facility region (northeast, midwest, south, west, unknown) and facility type defined by the American Cancer Society's Commission on Cancer Accreditation program (academic/research, community cancer, comprehensive community cancer, integrated network cancer, other/unknown). Radiation therapy was classified as combination, external beam, brachytherapy, or none/unknown.

Statistical Analysis

Frequency distributions between demographic and clinical characteristics of the patients and the scope of lymph node dissection were compared using χ^2 tests. The number of lymph nodes removed in the SLN group was reported descriptively as means (standard deviation [SD]), and medians (interquartile range [IQR]). To examine predictors of having undergone SLN mapping, we fit mixed-effect models adjusting for age, race, year of diagnosis, insurance status, income, location, comorbidity, facility type, region, stage, histology and grade to compare patients who underwent SLN mapping to those who underwent lymphadenectomy and to compare patients who underwent SLN mapping to who had no nodal assessment. The treating facility was included as random effect to account for hospital-level clustering.

To examine predictors of any type of radiation (external beam, brachytherapy or combination) among stage I patients who had SLN mapping or LND, we fit mixed-effect models adjusting for all demographic and clinical characteristics and scope of lymphadenectomy. A similar model was fit for predictors of external beam or combination radiation. To account for the data quality concerns in the accuracy of treatment data collected from more than one hospital in the NCDB, sensitivity analyses were performed limiting to patients who were reported from only one CoC-accredited hospital. All analyses

were conducted using SAS version 9.4 (SAS Institute Inc, Cary, North Carolina). All hypothesis testing was two-sided and a P -value of <0.05 was considered statistically significant.

Results

A total number 54,039 women were identified including 38,453 (71.2%) who underwent lymphadenectomy, 1929 patients (3.6%) who underwent sentinel lymph node (SLN) biopsy and 13,657 (25.3%) who did not undergo nodal assessment (Figure 1, Table 1). Among women treated in 2013, 2.8% underwent SLN biopsy, while 4.3% of those treated in 2014 underwent SLN biopsy ($P<0.001$). When limited to women who underwent some form of nodal assessment, either SLN biopsy or lymphadenectomy, 3.8% in 2013 and 5.8% in 2014 underwent SLN biopsy.

In the cohort of women who had SLN biopsy, 863 (45.4%) were coded as having only undergone SLN biopsy while 1038 (54.6%) underwent concurrent lymphadenectomy (Table 2). The median number of lymph nodes removed was 3 (IQR, 2–4) in those who underwent SLN biopsy alone and 14 (IQR, 9–21) in patients who had a concurrent nodal dissection.

Among women who underwent nodal assessment (either SLN biopsy or lymphadenectomy), a patient treated in 2014 was 60% more likely to undergo SLN biopsy than if that patients had been treated in 2013 (aRR=1.60; 95% CI, 1.46–1.76) (Table 3). Likewise, a patient treated at a community cancer center was 72% more likely to undergo SLN biopsy than if she was treated at an academic center (aRR=1.72; 95% CI, 1.04–2.86). In contrast, women with more advanced stage disease, sarcomas or carcinosarcomas, and those with poorly differentiated tumors were less likely to undergo SLN biopsy ($P<0.05$ for all). Similarly, compared to women treated in the northeast, those who received care in the Midwest and south were less likely to undergo SLN biopsy ($P<0.05$ for both).

When the analysis was limited to women who either underwent SLN biopsy or no nodal evaluation, women with 2 or more comorbidities (versus none) and those in the south (versus northeast) were less likely to undergo SLN biopsy ($P<0.05$ for both) (Table 3). Patients with moderate and poorly differentiated neoplasms (versus well differentiated) were more likely to undergo SLN biopsy.

Among women with stage I tumors who underwent nodal assessment, there was no association between use of SLN biopsy (compared to lymphadenectomy) and use of radiation (aRR=0.92; 95% CI, 0.82–1.05). Likewise, SLN biopsy was not associated with either external beam radiation alone or in combination with brachytherapy (aRR=0.98; 95% CI, 0.70–1.36) use. These results were unchanged in models limited to patients who received all care at only one facility.

Discussion

This study suggests that the use of sentinel lymph node biopsy for women with endometrial cancer is increasing. While a number of non-clinical factors contribute to uptake of SLN biopsy, women with non-endometrioid, poorly differentiated, and more advanced stage

tumors are less likely to undergo SLN biopsy and are still more likely to have lymphadenectomy. Performance of SLN biopsy in lieu of lymphadenectomy is not associated with a higher rate of use of adjuvant radiation.

Sentinel lymph node biopsy techniques have been developed to reduce the morbidity of nodal assessment for a variety of solid tumors and the procedure has recently been utilized for endometrial cancer. Initial data for the procedure was largely based on institutional case series, but more recently, multicenter prospective clinical trials have also reported the performance characteristics of SLN biopsy (9,16,17). The SENTI-ENDO study included 133 patients and reported a sensitivity of 84% and negative predictive value of 97% for sentinel lymph node biopsy (18). More recently, the FIRES trial enrolled 385 patients with endometrial cancer and reported successful sentinel lymph node mapping in 86% of subjects. The sensitivity for detection of nodal metastases was 97% with a negative predictive value of over 99% (19).

The role of any form of nodal assessment in endometrial cancer remains controversial. Two large, randomized trials both demonstrated that lymphadenectomy was not associated with improved survival (6,7). However, proponents of lymphadenectomy argue that the procedure allows not only prognostication but also allows more tailored adjuvant therapy (4,20). In the United States, many practitioners have shifted from universal lymphadenectomy to performance of the procedure in women with higher risk features (21).

In 2014, the National Comprehensive Cancer Network guidelines (22) included SLN biopsy as part of their accepted algorithm for staging. We noted that women with lower risk tumors (grade 1, superficially invasive) were more likely to undergo SLN biopsy and those with higher risk features preferentially underwent lymphadenectomy. While the value of nodal assessment in such low risk patients is questionable, surgeons may have been hesitant to apply a new technology to women at higher risk for nodal disease. While based on limited data, some studies have suggested that SLN mapping may also be used in higher risk histologic subtypes (23–25).

Encouragingly, these findings suggest that there was no association between use of SLN mapping and use of radiation in women with stage I tumors. A concern with implementation of SLN mapping is that clinicians may lack confidence in the ability of the technique to detect metastatic spread and prescribe adjuvant radiation therapy (4,26). These findings suggest that this is not the case. Women with stage I tumors who underwent SLN biopsy were no more likely to receive radiation therapy than those who underwent full lymphadenectomy.

In addition to clinical factors, we noted substantial regional variation in performance of SLN biopsy; patients in the northeast were much more likely to undergo the procedure than women in other parts of the U.S. Prior work has also demonstrated that patients undergoing robotic-assisted surgery are substantially more likely to undergo SLN mapping (27). SLN mapping is not unlike other new techniques and technologies in which non-clinical factors influence diffusion (28).

While the study benefits from the inclusion of a large cohort of patients, we recognize several important limitations. First, coding for sentinel lymph node biopsy for endometrial cancer in the NCDB is relatively new. As such, we cannot exclude the possibility of misclassification of a small number of women. Second, we are unable to capture women who had an attempted sentinel node biopsy but for technical reasons underwent only full lymphadenectomy. Technical considerations are an important consideration for any new surgical technique. Third, while we can account for a number of clinical and demographic characteristics, there are undoubtedly unmeasured confounding factors that influenced treatment choice and outcomes. Lastly, given the favorable prognosis of endometrial cancer, our study is underpowered to detect small differences in survival or use of radiation. Further work is clearly needed to further monitor the association between sentinel lymph node biopsy and use of adjuvant therapy and survival.

In conclusion, the use of sentinel lymph node mapping in endometrial cancer is increasing rapidly. There does not appear to be an association between use of sentinel lymph node dissection and use of adjuvant radiation. To date, the majority of the patients who underwent SLN mapping had low risk, early-stage tumors and more data is clearly needed among women with higher risk cancers. With increasing surgeons experience, improvements in detection rates and developing technology, SLN mapping will likely play a more prominent role in lymph node evaluation.

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Figure 1.
Flowchart of cohort selection

Table 1

Demographic and clinical characteristics of the patients by scope of lymph node dissection.

	No LND		Sentinel LN		LND		<i>P</i> -value
	N	%	N	%	N	%	
<i>All</i>	13,657	(25.3)	1,929	(3.6)	38,453	(71.2)	
<i>Age</i>							<0.001
<50	2,165	(15.9)	187	(9.7)	3,704	(9.6)	
50–59	4,201	(30.8)	565	(29.3)	10,499	(27.3)	
60–69	4,584	(33.6)	741	(38.4)	14,968	(38.9)	
70–79	1,758	(12.9)	342	(17.7)	7,233	(18.8)	
80	949	(6.9)	94	(4.9)	2,049	(5.3)	
<i>Race</i>							<0.001
White	10,716	(78.5)	1,508	(78.2)	30,167	(78.5)	
Black	1,269	(9.3)	126	(6.5)	3,894	(10.1)	
Hispanic	1,018	(7.5)	103	(5.3)	2,316	(6.0)	
Other	539	(3.9)	175	(9.1)	1,759	(4.6)	
Unknown	115	(0.8)	17	(0.9)	317	(0.8)	
<i>Year of diagnosis</i>							<0.001
2013	6,675	(48.9)	751	(38.9)	19,260	(50.1)	
2014	6,982	(51.1)	1,178	(61.1)	19,193	(49.9)	
<i>Insurance status</i>							<0.001
Private	7,134	(52.2)	1,045	(54.2)	18,820	(48.9)	
Medicare	4,711	(34.5)	728	(37.7)	15,234	(39.6)	
Medicaid	938	(6.9)	94	(4.9)	2,126	(5.5)	
Uninsured	545	(4.0)	28	(1.5)	1,314	(3.4)	
Other government/unknown	329	(2.4)	34	(1.8)	959	(2.5)	
<i>Income</i>							<0.001
<\$38,000	2,348	(17.2)	163	(8.4)	6,210	(16.1)	
\$38,000–\$47,999	3,066	(22.5)	314	(16.3)	8,670	(22.5)	
\$48,000–\$62,999	3,684	(27.0)	471	(24.4)	10,536	(27.4)	
\$63,000+	4,535	(33.2)	978	(50.7)	12,967	(33.7)	
Unknown	24	(0.2)	*	*	70	(0.2)	
<i>Education</i>							<0.001
21%	2,587	(18.9)	231	(12.0)	6,172	(16.1)	
13–20%	3,544	(26.0)	402	(20.8)	9,792	(25.5)	
7.0–12.9%	4,297	(31.5)	717	(37.2)	12,718	(33.1)	
<7%	3,211	(23.5)	576	(29.9)	9,715	(25.3)	
Unknown	18	(0.1)	*	*	56	(0.1)	
<i>Location</i>							<0.001
Metropolitan	11,108	(81.3)	1,642	(85.1)	31,225	(81.2)	
Urban	1,919	(14.1)	154	(8.0)	5,616	(14.6)	
Rural	224	(1.6)	*	*	701	(1.8)	

	No LND		Sentinel LN		LND		<i>P</i> -value
	N	%	N	%	N	%	
Unknown	406	(3.0)	127	(6.6)	911	(2.4)	
<i>Comorbidity</i>							<0.001
0	9,776	(71.6)	1,413	(73.3)	28,780	(74.8)	
1	3,068	(22.5)	458	(23.7)	7,941	(20.7)	
2	813	(6.0)	58	(3.0)	1,732	(4.5)	
<i>Facility type</i>							<0.001
Academic/research	5,501	(40.3)	1,027	(53.2)	16,204	(42.1)	
Community cancer	744	(5.4)	97	(5.0)	1,505	(3.9)	
Comprehensive community cancer	5,253	(38.5)	640	(33.2)	15,266	(39.7)	
Integrated network cancer	1,594	(11.7)	122	(6.3)	4,581	(11.9)	
Other/unknown	565	(4.1)	43	(2.2)	897	(2.3)	
<i>Facility region</i>							<0.001
Northeast	2,691	(19.7)	876	(45.4)	8,171	(21.2)	
Midwest	3,321	(24.3)	272	(14.1)	10,101	(26.3)	
South	4,546	(33.3)	460	(23.8)	12,637	(32.9)	
West	2,534	(18.6)	278	(14.4)	6,647	(17.3)	
Unknown	565	(4.1)	43	(2.2)	897	(2.3)	
<i>Stage</i>							<0.001
IA	9,682	(70.9)	1,271	(65.9)	20,588	(53.5)	
IB	1,531	(11.2)	276	(14.3)	7,447	(19.4)	
I NOS	1,175	(8.6)	63	(3.3)	1,470	(3.8)	
II	529	(3.9)	71	(3.7)	2,330	(6.1)	
IIIA	460	(3.4)	46	(2.4)	1,417	(3.7)	
IIIB	183	(1.3)	16	(0.8)	438	(1.1)	
IIIC	58	(0.4)	184	(9.5)	4,686	(12.2)	
III NOS	39	(0.3)	*	*	77	(0.2)	
<i>Histology</i>							<0.001
Endometrioid	10,900	(79.8)	1,519	(78.7)	27,578	(71.7)	
Serous	345	(2.5)	110	(5.7)	2,957	(7.7)	
Clear Cell	74	(0.5)	18	(0.9)	561	(1.5)	
Carcinosarcoma	284	(2.1)	51	(2.6)	1,794	(4.7)	
Sarcoma	547	(4.0)	12	(0.6)	550	(1.4)	
Other	1,507	(11.0)	219	(11.4)	5,013	(13.0)	
<i>Grade</i>							<0.001
Well	7,006	(51.3)	738	(38.3)	11,364	(29.6)	
Moderate	2,447	(17.9)	493	(25.6)	9,397	(24.4)	
Poorly	1,244	(9.1)	309	(16.0)	9,220	(24.0)	
Unknown	2,960	(21.7)	389	(20.2)	8,472	(22.0)	
<i>Radiation</i>							<0.001
None/unknown	11,963	(87.6)	1,405	(72.8)	25,720	(66.9)	
Combination	292	(2.1)	46	(2.4)	2,063	(5.4)	

	No LND		Sentinel LN		LND		<i>P</i> -value
	N	%	N	%	N	%	
External beam	518	(3.8)	112	(5.8)	3,086	(8.0)	
Brachytherapy	884	(6.5)	366	(19.0)	7,584	(19.7)	

* Cell size<10. NOS: not otherwise specified

Table 2

Number of sentinel lymph nodes removed in patients that had sentinel lymph nodes mapping.

	SLN only		SLN with LND	
<i>Number of sentinel LN removed</i>				
N	863		1,038	
Mean (SD)	4	(5)	16	(10)
Median (IQR)	3	(2–4)	14	(9–21)

1,901 patients in the sentinel LN group were included in the analysis. 28 patients, including 14 having SLN only, and 14 having SLN and LND) with unknown number were excluded.

SD: standard deviation.

IQR: interquartile range.

Table 3

Multivariable models for predictors of sentinel lymph node mapping.

		Sentinel LN vs LND	Sentinel LN vs No LND
		aRR	aRR
<i>Age</i>			
	<50	Referent	Referent
	50–59	1.08 (0.90–1.30)	1.06 (0.88–1.27)
	60–69	1.11 (0.92–1.34)	1.12 (0.93–1.35)
	70–79	1.04 (0.83–1.29)	1.18 (0.95–1.48)
	80	1.14 (0.86–1.51)	0.80 (0.60–1.06)
<i>Race</i>			
	White	Referent	Referent
	Black	0.84 (0.69–1.02)	0.88 (0.72–1.07)
	Hispanic	1.04 (0.84–1.28)	1.02 (0.82–1.27)
	Other	0.88 (0.72–1.08)	1.04 (0.84–1.29)
	Unknown	0.68 (0.42–1.10)	0.84 (0.52–1.38)
<i>Year of diagnosis</i>			
	2013	Referent	Referent
	2014	1.60 (1.46–1.76) *	1.36 (1.24–1.50) *
<i>Insurance status</i>			
	Private	Referent	Referent
	Medicare	1.02 (0.90–1.15)	0.94 (0.83–1.07)
	Medicaid	0.98 (0.79–1.22)	0.95 (0.76–1.19)
	Uninsured	0.74 (0.51–1.10)	0.69 (0.47–1.03)
	Other government/unknown	0.96 (0.67–1.36)	0.86 (0.61–1.23)
<i>Income</i>			
	<\$38,000	Referent	Referent
	\$38,000–\$47,999	1.18 (0.97–1.43)	1.08 (0.89–1.32)
	\$48,000–\$62,999	1.12 (0.92–1.35)	1.06 (0.88–1.28)
	\$63,000+	1.18 (0.97–1.42)	1.13 (0.93–1.37)
	Unknown	1.39 (0.44–4.46)	0.81 (0.25–2.63)
<i>Location</i>			
	Metropolitan	Referent	Referent
	Urban	0.87 (0.72–1.04)	0.90 (0.75–1.08)
	Rural	0.56 (0.25–1.26)	0.59 (0.26–1.34)
	Unknown	1.04 (0.80–1.34)	1.12 (0.87–1.45)
<i>Comorbidity</i>			
	0	Referent	Referent
	1	1.08 (0.97–1.20)	0.97 (0.87–1.09)
	2	0.77 (0.59–1.01)	0.68 (0.52–0.88) *
<i>Facility type</i>			
	Academic/research	Referent	Referent

	Sentinel LN vs LND	Sentinel LN vs No LND
	aRR	aRR
Community cancer	1.72 (1.04–2.86) *	1.07 (0.65–1.75)
Comprehensive community cancer	1.11 (0.79–1.57)	1.05 (0.75–1.47)
Integrated network cancer	0.92 (0.51–1.66)	0.91 (0.51–1.64)
Other/unknown	— ≠	— ≠
<i>Facility region</i>		
Northeast	Referent	Referent
Midwest	0.65 (0.43–0.99) *	0.72 (0.48–1.10)
South	0.58 (0.39–0.86) *	0.63 (0.42–0.93) *
West	0.64 (0.40–1.01)	0.66 (0.42–1.04)
Unknown	— ≠	— ≠
<i>Stage</i>		
IA	Referent	Referent
IB	0.78 (0.68–0.90) *	1.25 (1.09–1.44) *
I NOS	1.01 (0.77–1.32)	0.80 (0.60–1.05)
II	0.67 (0.53–0.86) *	1.04 (0.81–1.33)
IIIA	0.72 (0.54–0.97) *	0.90 (0.66–1.22)
IIIB	0.86 (0.52–1.43)	0.77 (0.46–1.28)
IIIC	0.69 (0.59–0.81) *	1.56 (1.32–1.84) *
III NOS	1.18 (0.29–4.85)	0.49 (0.12–2.00)
<i>Histology</i>		
Endometrioid	Referent	Referent
Serous	0.96 (0.77–1.19)	1.24 (0.99–1.54)
Clear Cell	0.74 (0.46–1.19)	1.15 (0.71–1.86)
Carcinosarcoma	0.74 (0.55–0.99) *	0.89 (0.66–1.21)
Sarcoma	0.54 (0.30–0.95) *	0.22 (0.13–0.40) *
Other	1.01 (0.87–1.17)	1.13 (0.98–1.32)
<i>Grade</i>		
Well	Referent	Referent
Moderate	0.91 (0.81–1.02)	1.35 (1.20–1.53) *
Poorly	0.70 (0.60–0.82) *	1.44 (1.23–1.69) *
Unknown	0.91 (0.79–1.04)	1.18 (1.02–1.35) *

aRR: adjusted risk ratio.

* P -value < 0.05.

≠ Unestimable due to multicollinearity between the unknown groups of facility type and facility region.

82.4% of all patients were reported from only one CoC-accredited hospital. Sensitivity analysis was performed limiting to those cases and showed similar results.

Table 4

Multivariable models for predictors of any type of radiation and external beam or combination among stage I patients who had sentinel lymph node mapping or lymphadenectomy.

	Any Radiation aRR	External Beam/Combination aRR
<i>Age</i>		
<50	Referent	Referent
50–59	1.32 (1.17–1.49) *	1.04 (0.80–1.34)
60–69	1.42 (1.25–1.60) *	1.08 (0.83–1.39)
70–79	1.46 (1.28–1.67) *	1.09 (0.82–1.44)
80	1.01 (0.86–1.18)	0.57 (0.40–0.82) *
<i>Race</i>		
White	Referent	Referent
Black	1.05 (0.97–1.15)	1.27 (1.08–1.51) *
Hispanic	1.02 (0.91–1.14)	1.14 (0.92–1.43)
Other	1.04 (0.93–1.17)	1.40 (1.11–1.77) *
Unknown	0.88 (0.68–1.15)	0.88 (0.49–1.58)
<i>Year of diagnosis</i>		
2013	Referent	Referent
2014	1.02 (0.98–1.07)	1.00 (0.90–1.10)
<i>Insurance status</i>		
Private	Referent	Referent
Medicare	1.05 (0.99–1.11)	1.02 (0.89–1.17)
Medicaid	0.99 (0.89–1.11)	1.17 (0.93–1.46)
Uninsured	0.97 (0.84–1.13)	1.15 (0.87–1.52)
Other government/unknown	0.94 (0.80–1.11)	1.02 (0.71–1.46)
<i>Income</i>		
<\$38,000	Referent	Referent
\$38,000–\$47,999	1.01 (0.94–1.10)	0.91 (0.77–1.08)
\$48,000–\$62,999	0.99 (0.91–1.07)	0.87 (0.74–1.03)
\$63,000+	1.03 (0.95–1.12)	0.85 (0.71–1.01)
Unknown	0.74 (0.39–1.39)	0.33 (0.05–2.40)
<i>Location</i>		
Metropolitan	Referent	Referent
Urban	1.00 (0.93–1.08)	0.88 (0.74–1.04)
Rural	1.18 (1.00–1.40)	1.01 (0.68–1.51)
Unknown	1.03 (0.88–1.21)	0.93 (0.63–1.37)
<i>Comorbidity</i>		
0	Referent	Referent
1	0.96 (0.90–1.01)	0.87 (0.76–1.00) *
2	0.88 (0.78–0.98) *	0.97 (0.76–1.24)

	Any Radiation aRR	External Beam/Combination aRR
<i>Facility type</i>		
Academic/research	Referent	Referent
Community cancer	1.04 (0.88–1.22)	2.17 (1.67–2.81) *
Comprehensive community cancer	1.06 (0.96–1.18)	1.44 (1.21–1.72) *
Integrated network cancer	1.11 (0.94–1.32)	1.38 (1.04–1.83) *
Other/unknown	__ ≠	__ ≠
<i>Facility region</i>		
Northeast	Referent	Referent
Midwest	0.86 (0.75–0.97) *	1.25 (1.01–1.56) *
South	0.64 (0.56–0.72) *	0.89 (0.71–1.11)
West	0.68 (0.59–0.79) *	0.93 (0.72–1.18)
Unknown	__ ≠	__ ≠
<i>Stage</i>		
IA	Referent	Referent
IB	2.93 (2.80–3.07) *	5.98 (5.33–6.71) *
I NOS	0.98 (0.85–1.13)	1.79 (1.34–2.39) *
<i>Histology</i>		
Endometrioid	Referent	Referent
Serous	1.11 (1.02–1.20) *	1.01 (0.83–1.23)
Clear Cell	1.21 (1.01–1.44) *	1.46 (1.00–2.13) *
Carcinosarcoma	1.10 (0.99–1.22)	1.78 (1.48–2.14) *
Sarcoma	0.31 (0.23–0.40) *	0.71 (0.51–0.99) *
Other	1.10 (1.03–1.17) *	1.16 (1.00–1.35) *
<i>Grade</i>		
Well	Referent	Referent
Moderate	1.90 (1.77–2.03) *	2.08 (1.72–2.50) *
Poorly	3.01 (2.80–3.23) *	5.39 (4.52–6.44) *
Unknown	1.86 (1.72–2.01) *	2.57 (2.12–3.12) *
<i>Scope of lymph node dissection</i>		
Lymphadenectomy	Referent	Referent
Sentinel lymph node mapping	0.92 (0.82–1.05)	0.98 (0.70–1.36)

aRR: adjusted risk ratio.

* P -value < 0.05.

≠ Unestimable due to multicollinearity between the unknown groups of facility type and facility region.