Trends and survival outcomes of robotic, laparoscopic, and open surgery for stage II uterine cancer

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HIGHLIGHTS

- Women with stage II uterine cancer have similar 5-year survival after minimally invasive and open hysterectomy
- The use of minimally invasive surgery for stage II uterine cancer increased between 2010 and 2015
- Black women with stage II uterine cancer have more open hysterectomies and worse 5-year survival

ABSTRACT

Introduction A recent randomized clinical trial showed that minimally invasive surgery led to poorer survival compared with open surgery in early stage cervical cancer. We determined the trends in adoption of minimally invasive surgery and 5-year overall survival outcomes after open, laparoscopic-assisted, and robotic-assisted hysterectomy for stage II uterine cancer with cervical stromal involvement.

Methods Data for patients with stage II uterine cancer were acquired from the National Cancer Database from 2010 to 2015. χ^2 testing, Kaplan–Meier methods, and Cox models were used for statistical analyses.

Results Of 2949 patients, 44.3% underwent open hysterectomy, 13.9% underwent laparoscopic hysterectomy, and 41.8% underwent robotic hysterectomy. The proportion of robotic cases increased from 26.8% in 2010 to 48.3% in 2015 (annual percent change 10.1%), with a decrease in open hysterectomy from 63.3% to 34.3% (annual percent change –12.5%). The overall 5-year survival was 77.6% in robotic, 76.8% in laparoscopic, and 72.5% in open hysterectomy ($p=0.045$); however, after adjusting for known prognostic factors, robotic (HR 1.00, 95% CI 0.82 to 1.21; $p=0.97$) and laparoscopic hysterectomy (HR 1.09, 95% CI 0.83 to 1.44; $p=0.54$) did not portend for improved survival compared with open hysterectomy. Black women (HR 1.59, 95% CI 1.25 to 2.02; $p<0.001$) and individuals with co-morbidities (HR 1.45, 95% CI 1.21 to 1.75, $p<0.001$) had worse adjusted survival and the highest rates of open hysterectomy.

Conclusion The use of minimally invasive surgery for stage II uterine cancer has increased over time, with comparable adjusted 5-year survival after robotic or laparoscopic hysterectomy compared with open hysterectomy. Black women and those with co-morbidities had lowest rates of minimally invasive surgery and the poorest adjusted survival.

INTRODUCTION

Uterine cancer is the most common gynecologic malignancy in the USA, with an estimated 66 650 new cases and 12 590 deaths projected in 2020.¹

Recommended surgical management includes a total hysterectomy, bilateral salpingectomy-oophorectomy, and lymphadenectomy for endometrioid histological subtypes and more extensive surgery, including a partial omentectomy, for serous and clear cell subtypes.² There has been increased adoption of minimally invasive surgery through a laparoscopic approach, primarily fueled by shorter recovery, lower wound complications, and improved quality of life.^{3,4}

Two randomized clinical trials have found that the use of laparoscopic hysterectomy results in equivalent overall survival to open hysterectomy in patients with early stage uterine cancer.^{3,5} However, neither of these studies included the use of robotic surgery, a method of minimally invasive surgery that has been widely adopted across the USA and is used at a rate of 25% at high-volume centers for uterine cancer.⁶ Moreover, these studies excluded patients with stage II uterine cancer with cervical stromal involvement, which has a higher risk of recurrence than stage I disease.⁷ This issue is particularly pertinent given a recent randomized controlled trial showing that minimally invasive surgery was associated with poorer survival compared with open surgery in patients with early stage cervical cancer.⁸ Given the concerns regarding the increased risk of death associated with minimally invasive surgery in early stage cervical cancer, there may exist a similar underlying risk in the use of minimally invasive surgery in stage II uterine cancer with cervical involvement. Thus, the safety of minimally invasive surgery, and particularly robotic surgery, warrants further investigation.

In addition to survival outcomes, trends and disparities in the adoption of minimally invasive surgery for the treatment of uterine cancer is an area of active investigation. Current research on the use of minimally invasive surgery in the treatment of uterine cancer has either not been stratified by stage of disease or has predominantly included patients with stage I uterine cancer.^{6,9,10} Whether the trends seen in

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stage I uterine cancer are reflected in stage II disease is unknown and requires further research, particularly because randomized controlled trials are not feasible to perform given the relatively low incidence of stage II uterine cancer.^{10–12}

Using the National Cancer Database, we evaluated the 5-year overall survival after open, laparoscopic-assisted, and robotic-assisted hysterectomy in a large cohort of patients with locally advanced stage II uterine cancer. In addition, we assessed the trends of surgery in stage II uterine cancer based on race, ethnicity, insurance status, and other socio-economic factors to evaluate whether disparities exist in this study population.

METHODS

Data source

The National Cancer Database was established in 1989 and is a nationwide, facility-based, comprehensive clinical surveillance resource and oncology dataset. The data represent more than 70% of newly diagnosed cancer cases in the USA and include information on patient demographics, clinical characteristics, treatment, and outcomes.^{13 14} National Cancer Database Participant User Files from 2010 to 2015 were abstracted in this analysis. Because the data used in this study are derived from a de-identified National Cancer Database file, no institutional review board approval was required.

Cohort selection and characteristics

Our cohort consisted of patients diagnosed with stage II uterine cancer between 2010 and 2015 who underwent simple or radical hysterectomy. Disease was categorized based on the International Classification of Diseases for Oncology 3rd edition, and the stage of disease was based on the American Joint Committee on Cancer 7th edition. We excluded individuals who did not undergo a pelvic and para-aortic lymphadenectomy, those who were missing surgical approach or lymphadenectomy information, and those who received neoadjuvant chemotherapy or pre-operative radiation therapy.

Patient characteristics abstracted from the database included age at diagnosis, race, insurance, educational attainment of individual's area of residence (defined as percent of adults age 25 or older in the individual's zip code who did not graduate from high school), Charlson–Deyo Comorbidity Index Score, and region of the USA. Healthcare facility type was designated based on the Commission on Cancer and included community cancer programs (100–500 newly diagnosed cancer cases each year with full range of diagnostic and treatment services), comprehensive community cancer programs (more than 500 newly diagnosed cancer cases each year with full range of diagnostic and treatment services), Academic/Research Programs (participates in postgraduate medical education), and integrated network cancer programs (system of facilities that provide integrated cancer care and is characterized by a unified cancer committee). Clinical characteristics included histological cell type, tumor grade, tumor size, lymphovascular invasion, surgical margin, and adjuvant treatment. Type of surgery was categorized as either open, laparoscopic-assisted, or robotic-assisted. Type of surgery was maintained as laparoscopic or robotic even when conversion to an open approach occurred, as has been referenced in prior literature.¹⁵

Statistical analysis

We compared baseline patient characteristics between the surgical approaches using χ^2 and ANOVA tests to examine the relationship between categorical and continuous variables, respectively. Annual percent change was used to measure the trend in surgical approaches over time using the Joinpoint Regression Program (Version 4.6.0.0) of the National Cancer Institute.¹⁶ Kaplan–Meier methods were used for univariate analysis, and the log-rank test was used to make comparisons of overall survival based on treatment modality. Multivariate analyses with hazard ratios (HRs) and 95% confidence intervals (CIs) were estimated using Cox proportional hazards regression to assess the relationship of surgical treatment modality and 5-year overall survival after adjusting for important demographic, clinico-pathologic, and treatment factors. Statistical analyses were performed with SPSS software (Version 26).

RESULTS

Clinical and demographic patient characteristics

Between 2010 and 2015, 2949 patients were diagnosed with stage II uterine cancer and received open, laparoscopic, or robotic hysterectomy with pelvic and para-aortic lymphadenectomy. The demographic and clinico-pathologic characteristics of the study population are shown in Table 1. The median age of the cohort was 64 years (range 25–90). Whites, Blacks, Hispanic, Asian/Pacific Islanders, and other races comprised 75.4%, 13.0%, 7.1%, 3.0%, and 1.6% of the population, respectively. Overall, 22.8% of patients resided in the Northeast, while 29.7%, 32.3%, and 15.2% resided in the Midwest, South, and West, respectively. Ninety three percent of patients had insurance and 26.6% had a Charlson–Deyo Comorbidity Index Score of ≥ 1 .

Trends by route of hysterectomy

The majority of patients underwent either open (44.3%) or robotic hysterectomy (41.8%), and the remainder underwent laparoscopic hysterectomy (13.9%, Table 1). We analyzed the changes in surgical method across the study timeframe. The proportion of robotic hysterectomies increased from 26.8% in 2010 to 48.3% in 2015, with an annual percent change of 10.1% ($p < 0.05$, Figure 1). There was a corresponding decrease in open hysterectomy from 63.3% to 34.3% (annual percent change -12.5% , $p < 0.05$), while laparoscopic hysterectomy showed an increase from 9.9% to 17.4% (annual percent change 11.2%).

White individuals were more likely to undergo robotic hysterectomy (44.4%) than black (31.4%), Hispanic (36.2%), and Asian/Pacific Islander individuals (33.3%, $p < 0.001$; Table 1, online supplementary figure 1). Black women had the highest rates of open hysterectomy at 54.2%, while Hispanic women had the highest rates of laparoscopic hysterectomy at 19.5%. Patients seen in integrated network cancer programs had the highest rate of robotic hysterectomy (45.2%), and those receiving care in community cancer programs had the highest rate of open hysterectomy (56.1%; $p = 0.043$). Individuals with insurance were also more likely to undergo robotic hysterectomy than those who were uninsured (42.8% vs 28.8%; $p = 0.004$). Additionally, those with a higher rate of educational attainment in their area of residence (no high school degree $< 13\%$ (44.8%) vs $> 13\%$ (36.7%); $p < 0.001$) and those with

Table 1 Patient demographics by route of hysterectomy

	Open	Laparoscopic	Robotic	Total	P value
	n (%)	n (%)	n (%)	n (%)	
No of cases	1305 (44.3)	410 (13.9)	1234 (41.8)	2949 (100)	
Age, years					0.891*
Mean±SD	63.17±11.30	63.21±11.01	63.34±10.71	63.25±11.01	
Median	63	64	64	64	
Min–Max	25–90	28–90	31–90	25–90	
Race					<0.001
White	947 (42.6)	289 (13.0)	987 (44.4)	2223 (100)	
Black	207 (54.2)	55 (14.4)	120 (31.4)	382 (100)	
Hispanic	93 (44.3)	41 (19.5)	76 (36.2)	210 (100)	
Asian/Pacific Islander	43 (49.4)	15 (17.2)	29 (33.3)	87 (100)	
Other/unknown	15 (31.9)	10 (21.3)	22 (46.8)	47 (100)	
Region of the USA					<0.001
Northeast	310 (46.1)	96 (14.3)	266 (39.6)	672 (100)	
Midwest	387 (47.0)	70 (8.5)	367 (44.5)	824 (100)	
South	411 (43.2)	145 (15.2)	396 (41.6)	952 (100)	
West	173 (38.5)	91 (20.3)	185 (41.2)	449 (100)	
Unknown	24 (46.2)	8 (15.4)	20 (38.5)	52 (100)	
Healthcare facility type					0.043
Community cancer program	46 (56.1)	8 (9.8)	28 (34.1)	82 (100)	
Comprehensive community cancer program	429 (41.5)	159 (15.4)	445 (43.1)	1033 (100)	
Academic/research program	613 (46.1)	181 (13.6)	537 (40.3)	1331 (100)	
Integrated network cancer program	193 (42.8)	54 (12.0)	204 (45.2)	451 (100)	
Insurance status					0.004
No	90 (55.2)	26 (16.0)	47 (28.8)	163 (100)	
Yes	1195 (43.4)	380 (13.8)	1177 (42.8)	2752 (100)	
Unknown	20 (58.8)	4 (11.8)	10 (29.4)	34 (100)	
No high school degree 2008–2012, %					<0.001
≥13%	547 (49.2)	157 (14.1)	408 (36.7)	1112 (100)	
<13%	724 (41.5)	239 (13.7)	782 (44.8)	1745 (100)	
Charlson–Deyo Comorbidity Index Score					0.001
0	922 (42.6)	293 (13.5)	949 (43.9)	2164 (100)	
≥1	383 (48.8)	117 (14.9)	285 (36.3)	785 (100)	

Data are n (%) unless otherwise specified.

Percentages are in row percent, and proportions were compared using χ^2 tests.

*A t-test was used to calculate p values for the mean difference of age (years) for open vs laparoscopic vs robotic surgery.

no co-morbidities (43.9% for Charlson–Deyo Comorbidity Index Score 0 vs 36.3% for individuals with Charlson–Deyo Comorbidity Index Score 1; $p=0.001$) were also more likely to undergo robotic hysterectomy. Compared with white patients, black patients were more likely to have more co-morbidities (34.6% vs 24.2%; $p<0.001$), lack insurance (8.1% vs 3.6%), and receive care at academic/research programs (54.0% vs 44.3%; $p<0.001$) or integrated network cancer programs (17.6% vs 15.7%; $p<0.001$).

Mean tumor size was 6.20 cm with open hysterectomy, 5.82 cm in laparoscopic hysterectomy, and 5.69 cm in robotic hysterectomy ($p<0.001$, Table 2). Individuals with endometrioid carcinoma were

more likely to undergo robotic hysterectomy (44.2%) than those with non-endometrioid carcinoma sub-types (serous carcinoma: 41.1%, clear cell carcinoma: 32.7%, carcinosarcoma: 27.6%; $p<0.001$). This trend was not as pronounced for laparoscopic hysterectomy (endometrioid carcinoma: 14.4%, serous carcinoma: 14.8%, clear cell carcinoma: 9.6%; carcinosarcoma: 10.0%). Patients with poorly differentiated tumors had the highest rates of open hysterectomy (51.1%), while laparoscopic and robotic approaches were used most frequently for moderately differentiated tumors (15.6%) and well differentiated tumors (47.7%), respectively ($p<0.001$). Laparoscopic hysterectomy was performed most frequently for <2 cm

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Figure 1 Trends by route of hysterectomy from 2010 to 2015 in the USA. * indicates that the annual percent change (APC) is significantly different from zero at the $\alpha=0.05$ level.

while robotic hysterectomy was used for intermediate tumors of 2–4 cm (48.9%, $p<0.001$).

Survival analysis and treatment

The 5-year survival rate by surgical method is shown in Figure 2. The unadjusted 5-year survival rate was highest for robotic hysterectomy (77.6%), followed by laparoscopic hysterectomy (76.8%) and open hysterectomy (72.5%; $p=0.045$). To evaluate the effect of demographic factors and route of hysterectomy on 5-year survival, we used a Cox proportional hazards regression model that included important demographic, clinico-pathologic, and treatment factors. After adjusting for these factors, there was no association between survival and surgical method (laparoscopic vs open: HR 1.09, 95% CI 0.83 to 1.44; $p=0.54$; robotic vs open: HR 1.00, 95% CI 0.82 to 1.21; $p=0.97$, Table 3).

Black compared with white race (HR 1.59, 95% CI 1.25 to 2.02; $p<0.001$) and having a Charlson–Deyo Comorbidity Index Score of 1 versus 0 (HR 1.45, 95% CI 1.21 to 1.75; $p<0.001$) were associated with worse adjusted 5-year overall survival (Table 3). Additionally, individuals with carcinosarcoma compared with endometrial carcinoma (HR 1.70, 95% CI 1.29 to 2.24; $p<0.001$) and those with lymphovascular invasion (HR 1.71, 95% CI 1.42 to 2.06; $p<0.001$) had worse survival. Receiving either adjuvant radiation therapy alone (HR 0.69, 95% CI 0.54 to 0.87; $p=0.002$) or adjuvant radiation therapy and chemotherapy (HR 0.63, 95% CI 0.48 to 0.82, $p=0.001$) resulted in improved 5-year survival compared with those who did not receive adjuvant therapy. Surgical field, tumor size, and surgical margin status were not associated with improved or worsened survival.

DISCUSSION

Uterine cancer is the most common pelvic gynecologic malignancy in the USA, with a rising incidence and an increase in mortality rate of 1.1% per year over the past two decades.¹⁷ Although prior studies have evaluated the management of stage II uterine cancer with cervical stromal involvement, there is currently limited literature that evaluates the effect of minimally invasive surgical techniques on survival outcomes in stage II uterine cancer, which is particularly important given recent literature suggesting reduced survival with the use of minimally invasive surgery in the treatment of early stage cervical cancer.^{8 18–20} In our retrospective cohort study of 2949 patients, we found that minimally invasive approaches including laparoscopic and robotic hysterectomy appear to have comparable adjusted 5-year survival outcomes to open hysterectomy for stage II uterine cancer. Moreover, individuals who are often underserved by our healthcare system, including black and uninsured patients, have limited access to minimally invasive surgery for the treatment of stage II uterine cancer.

In two randomized controlled trials, minimally invasive approaches were found to have equivalent survival outcomes to an open approach for early stage uterine cancer.^{3–5} Walker et al found no difference in disease-free or overall survival for patients undergoing laparoscopy versus open hysterectomy for stage I or IIA uterine cancer.^{4 5} Moreover, Janda et al randomized patients with stage I disease to receive laparoscopic or open hysterectomy and found no difference in recurrence rates or overall survival.³ However, patients with stage II disease with cervical involvement were excluded from these trials.⁷ As such, the safety and efficacy of minimally invasive surgery in this population has not been well studied.

Surgical route has been studied in the setting of cervical cancer and may shed light on the most appropriate surgical treatment for uterine cancer with cervical involvement. While retrospective studies have found no difference in the rate of recurrence or death following robotic or laparoscopic hysterectomy compared with open hysterectomy for cervical cancer,^{8 21–23} a recent pivotal prospective randomized controlled trial of 319 women with early stage cervical cancer found that minimally invasive surgery, which included both laparoscopic and robotic approaches, had a lower rate of disease-free survival and overall survival than open abdominal radical hysterectomy.⁸ In this current analysis of stage II uterine cancer with cervical involvement, our results did not show decreased survival associated with minimally invasive surgery. There are a number of reasons why this might be the case. It is possible that the location of the tumor in uterine cancer generally remains contained in the corpus while the majority of cervical cancer tumors are exophytic and exposed to the vaginal cavity. When a surgeon enters the vagina with a minimally invasive approach, the insufflation of carbon dioxide gas may facilitate local spread of cervical cancer from the enclosed vaginal cavity into the peritoneum. In contrast, in most uterine cancers the ectocervix remains uninvolved and may contain the tumor within the uterine cavity, thereby minimizing the risk of spread during minimally invasive surgery. The effect of insufflation on tumor cell growth has also been discussed in prior studies; however, the cervical involvement in stage II uterine cancer is not in direct contact with the gas and may not promote tumor growth.^{24 25}

Table 2 Tumor characteristics by route of hysterectomy

	Open	Laparoscopic	Robotic	Total	P value
	n (%)	n (%)	n (%)	n (%)	
No of cases	1305 (44.3)	410 (13.9)	1234 (41.8)	2949 (100)	
Surgical field					<0.001
Simple hysterectomy	1100 (42.5)	373 (14.4)	1115 (43.1)	2588 (100)	
Radical hysterectomy	205 (56.8)	37 (10.2)	119 (33.0)	361 (100)	
Histology					<0.001
Endometrioid carcinoma	907 (41.3)	317 (14.4)	970 (44.2)	2194 (100)	
Serous carcinoma	164 (44.1)	55 (14.8)	153 (41.1)	372 (100)	
Clear cell carcinoma	60 (57.7)	10 (9.6)	34 (32.7)	104 (100)	
Carcinosarcoma	174 (62.4)	28 (10.0)	77 (27.6)	279 (100)	
Grade					<0.001
Well differentiated	186 (37.6)	73 (14.7)	236 (47.7)	495 (100)	
Moderately differentiated	339 (40.9)	129 (15.6)	360 (43.5)	828 (100)	
Poorly differentiated	627 (51.1)	156 (12.7)	443 (36.1)	1226 (100)	
Unknown	153 (38.3)	52 (13.0)	195 (48.8)	400 (100)	
Tumor size (cm)					
Mean±SD	6.20±5.28	5.82±1.02	5.10±13.41	5.69±4.80	<0.001*
Tumor size stratified (cm)					<0.001
<2	90 (38.3)	41 (17.4)	104 (44.2)	235 (100)	
≥2 and <4	259 (36.6)	103 (14.5)	346 (48.9)	708 (100)	
≥4	767 (48.1)	211 (13.2)	617 (38.7)	1595 (100)	
Unknown	189 (46.0)	55 (13.4)	167 (40.6)	411 (100)	
Lymphovascular invasion					0.258
No	799 (44.9)	227 (12.7)	755 (42.4)	1781 (100)	
Yes	409 (43.1)	148 (15.6)	393 (41.4)	950 (100)	
Unknown	97 (44.5)	35 (16.1)	86 (39.4)	218 (100)	
Surgical margin					0.518
Negative	1192 (44.2)	376 (13.9)	1128 (41.8)	2696 (100)	
Positive	30 (42.3)	6 (8.5)	35 (49.3)	71 (100)	
Unknown	83 (45.6)	28 (15.4)	71 (39.0)	182 (100)	
Adjuvant treatment					0.001
No	341 (47.6)	97 (13.5)	279 (38.9)	717 (100)	
Chemotherapy only	142 (50.9)	35 (12.5)	102 (36.6)	279 (100)	
Radiation therapy only	475 (39.5)	171 (14.2)	556 (46.3)	1202 (100)	
Radiation therapy and chemotherapy	297 (47.1)	83 (13.2)	251 (39.8)	631 (100)	
Unknown	50 (41.7)	24 (20.0)	46 (38.3)	120 (100)	

Data are n (%) unless otherwise specified.

Percentages are in row percent, and proportions were compared using χ^2 tests.

*A t-test was used to calculate p values for the mean difference of tumor size (cm) for open vs laparoscopic vs robotic surgery.

Although we found that minimally invasive approaches have comparable survival outcomes to open hysterectomy in our retrospective analysis, it is important to note that individuals who are marginalized by the healthcare system did not have the same rates of minimally invasive surgery. For example, black women had higher rates of open hysterectomy compared with laparoscopic and robotic hysterectomy, and black race remained an independent

predictor for poorer survival even after adjusting for surgery type, grade, histology, and other socio-demographic, clinico-pathologic, and treatment factors. This is consistent with prior studies that have shown limited access to minimally invasive techniques and worse outcomes in black women with uterine cancer, cervical cancer, and benign conditions like fibroids and prolapse.^{6 12 26–28} However, it is important to note that this relationship is complex and

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Figure 2 Five-year unadjusted survival estimates by route of hysterectomy.

likely dependent on other factors that are not accounted for in large databases, including the effect of implicit bias, healthcare literacy, and historical racism in the healthcare system. Additionally, individuals without insurance were less likely to receive robotic hysterectomy than laparoscopic and open hysterectomy. As noted in a paper by Jacoby et al, for women undergoing hysterectomy without private insurance relying on either 'no charge/charity' or self-pay options, there may be an incentive to avoid laparoscopy or robotic surgery to limit cost to the hospital or patient.¹² Further studies that incorporate both the molecular characteristics of these tumors and socio-economic and historical factors associated with survival are necessary to fully understand these disparities.^{29–31}

This study was limited due to the retrospective nature of the research, which precludes us from making definitive treatment recommendations. Ultimately, randomized controlled trials are needed to thoroughly evaluate the effect of surgical approach on survival outcomes for patients with stage II uterine cancer with cervical stromal involvement. However, given the limited number of stage II uterine cancer diagnoses in the USA, this may prove challenging. For example, even after combining patients with stages I and IIA uterine cancer, the LAP2 trial required nearly a decade to enroll 2616 patients.⁴ Importantly, given the limitations of the dataset, we were unable to determine whether the diagnosis of stage II uterine cancer was made pre-operatively or post-operatively, which could have influenced the surgeon's decision to use a minimally invasive surgery versus open approach with a simple or radical hysterectomy. Additionally, physician skill set, years in practice, access to robotic surgical devices, physician rationale, and prior training, including training in minimally invasive surgical techniques, may have influenced the choice of surgical method, and future studies are needed to evaluate this impact. We

did not adjust for parametrial involvement of uterine cancer in our study. Finally, due to the limitations of our database, we were only able to analyze overall survival rather than progression-free survival or disease-specific survival. For example, we know that individuals with uterine cancer are most likely to die from cardiovascular disease, not uterine cancer; however, we were unable to assess this effect in our population.^{32,33} Despite these limitations, our study contributes to the current understanding of the effect of surgical approach on survival outcomes in stage II uterine cancer, particularly due to the large sample size, national representation, and inclusion of the robotic approach in minimally invasive techniques. More studies on long-term outcomes of minimally invasive surgery for stage II uterine cancer, including length of hospital stay, post-operative complications, re-admission rates, and overall economic impact on the healthcare system, are needed to appreciate the larger implications of choice of surgical method in the treatment of this disease.

CONCLUSION

The choice of route of hysterectomy for the treatment of stage II uterine cancer with cervical involvement should be based on a number of factors, including patient and provider preference and the unique clinical presentation. However, as the rate of minimally invasive surgery increases, it is important to evaluate the possible disparities and differences in survival outcomes from the utilization of this technique. Our study shows that minimally invasive hysterectomy has comparable 5-year survival outcomes to open hysterectomy for stage II uterine cancer; moreover, we found that minimally invasive surgery is used less commonly in black patients and those with co-morbidities.

Table 3 Multivariate analysis

Factors	HR	95% CI	P value
Surgical method			
Open	Ref		
Laparoscopic	1.09	0.83 to 1.44	0.538
Robotic	1.00	0.82 to 1.21	0.970
Facility type			
Community cancer program	Ref		
Comprehensive community cancer program	1.00	0.57 to 1.75	0.996
Academic/research program	0.97	0.55 to 1.70	0.906
Integrated network cancer program	0.81	0.45 to 1.46	0.485
Region			
Northeast	Ref		
Midwest	1.21	0.95 to 1.53	0.118
South	0.86	0.67 to 1.10	0.234
West	1.07	0.79 to 1.45	0.676
Race			
White	Ref		
Black	1.59	1.25 to 2.02	0.000
Hispanic	0.86	0.55 to 1.32	0.481
Asian/Pacific Islander	1.15	0.65 to 2.02	0.629
Other/unknown	1.00	0.47 to 2.11	0.991
Insurance or not			
No	Ref		
Yes	0.99	0.60 to 1.63	0.966
Unknown	0.80	0.26 to 2.43	0.694
No high school degree 2008–2012, %			
≥13%	Ref		
<13%	1.10	0.90 to 1.33	0.352
Charlson–Deyo Comorbidity Index Score			
0	Ref		
≥1	1.45	1.21 to 1.75	0.000
Surgical field			
Simple hysterectomy	Ref		
Radical hysterectomy	0.92	0.70 to 1.22	0.567
Histology			
Endometrioid carcinoma	Ref		
Serous carcinoma	0.89	0.66 to 1.20	0.442
Clear cell carcinoma	0.71	0.43 to 1.17	0.180
Carcinosarcoma	1.70	1.29 to 2.24	0.000
Grade			
Well differentiated	Ref		
Moderately differentiated	1.50	1.03 to 2.20	0.037
Poorly differentiated	3.12	2.13 to 4.57	0.000
Unknown	1.58	1.02 to 2.45	0.041
Tumor size (cm)			
<2	Ref		
≥2 and <4	0.94	0.63 to 1.39	0.754

Continued

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Table 3 Continued

Factors	HR	95% CI	P value
≥4	1.17	0.80 to 1.69	0.418
Unknown	1.23	0.81 to 1.87	0.326
Lymphovascular invasion			
No	Ref		
Yes	1.71	1.42 to 2.06	0.000
Unknown	0.88	0.60 to 1.30	0.528
Surgical margin			
Negative	Ref		
Positive	1.27	0.78 to 2.07	0.343
Unknown	1.11	0.77 to 1.60	0.566
Adjuvant therapy			
No	Ref		
Chemotherapy only	0.79	0.58 to 1.08	0.135
Radiation therapy only	0.69	0.54 to 0.87	0.002
Radiation therapy and chemotherapy	0.63	0.48 to 0.82	0.001
Unknown	0.87	0.57 to 1.34	0.539

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