

Survival after Laparoscopic Radical Surgery for Early-stage Cervical Cancer in 1316 Consecutive Cases from a National Laparoscopic Training Center in China

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Research

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Abstract

Background: A major concern about the Laparoscopy Approach to Cervical Cancer trial is the disparities in laparoscopic radical hysterectomy experience between the participating centers and the potential effects of the learning curve of minimally invasive surgery on the oncologic outcomes of patients. Thus, it is necessary to assess the survival of cervical cancer patients undergoing laparoscopy in a minimally invasive gynecology center.

Methods: A consecutive series of patients undergoing first laparoscopic radical hysterectomy (LRH) for cervical cancer from May 2008 to December 2017 at a national laparoscopic training center were retrospectively analyzed. The overall survival (OS) and progression-free survival (PFS) were compared between groups.

Results: In total, 1316 women with FIGO (2009) stage IA-IIB cervical cancer received LRH. Among them, 1114 (84.7%) were followed-up for 3 months or longer; the median follow-up period was 48 months (range, 3-144 months). In patients with stage IA, IB1 (≤ 2 cm), IB1 (> 2 cm), IB2, IIA1 and IIA2-IIB tumors, the 4-year PFS rates were 98.6%, 94.5%, 87.4%, 65.6%, 80.0% and 67.4%, respectively, and the 4-year OS rates were 98.6%, 96.8%, 91.1%, 77.4%, 85.6% and 76.2%, respectively. The 4-year PFS and OS were as high as 96.2% and 97.5%, respectively, in patients with squamous cell carcinoma of 2 cm or smaller in diameter. A stable high 4-year OS and PFS was achieved after completing 100 LRHs. In patients operated on by the same surgeon, an improvement in survival was observed after 40 LRHs.

Conclusion: Favorable oncologic outcomes can be achieved in patients with IA-IB1 cervical cancer after LRH in a center with a high surgery volume.

Background

Minimally invasive surgery, in comparison to laparotomy, has been associated with fewer perioperative complications and shorter postoperative convalescence periods and is widely used in the treatment of solid tumors (1–3). However, the use of laparoscopic radical hysterectomy (LRH) in the treatment of early stage cervical cancer dramatically decreased after the Laparoscopy Approach to Cervical Cancer (LACC) study data were released in 2018, which indicated a significantly increased risk for recurrence and death after minimally invasive surgery over open surgery (4). Subsequently, multiple non-randomized studies and meta-analyses comparing laparoscopy to laparotomy for cervical cancer regarding oncologic safety were published. Unfortunately, controversies exist across studies, and a consensus has not been achieved (2, 5, 6). Therefore, it is still an open question whether minimally invasive surgery causes inferior oncologic outcomes in patients with early stage cervical cancer.

A major concern about the LACC trial is the disparities in LRH experience between the participating centers across the world and the potential effects of the learning curve of minimally invasive surgery on the oncologic outcomes of patients (7–9). Thus, it is necessary to assess the survival of cervical cancer patients undergoing laparoscopy in centers with surgeons who are highly experienced in minimally

invasive surgery. In our center, a national training base of laparoscopic surgery techniques in China, the first-ever laparoscopic radical surgery for cervical cancer was performed in May 2008. Since then, patients with early stage cervical cancer have been preferentially subjected to LRH after careful staging and receiving informed consent. Here, we show the progression-free survival (PFS) and the overall survival (OS) of 1316 patients who received LRH at our hospital and the impacts of clinicopathological factors and learning curves on survival after minimally invasive surgery, providing evidence for deciding the appropriate surgical approach for cervical cancer and encouraging discussion in the post-LACC era.

Methods

Study Design and Patients

This study was a retrospective analysis involving a consecutive series of 1316 patients receiving LRH for cervical cancer at our center from May 2008 to December 2017. All patients with pathologically confirmed primary cervical cancer undergoing LRH were included, including those who had neoadjuvant chemotherapy before surgery because of bulky tumors, while those for whom the planned LRHs were abandoned because of intra-operatively detected inoperability were excluded. The study was approved by the Ethics Committee of the Tongji Medical College, Huazhong University of Science and Technology (No. 2020S246).

Treatment Of Patients

Before surgery, the diagnosis of cervical cancer was histologically confirmed by cervix biopsy or conization, and the spread of disease was staged by physical examination combined with imaging tests, including chest X-ray, pelvic magnetic resonance imaging (MRI) or computed tomography (CT), pelvic ultrasound and positron emission tomography (PET), as appropriate. The staging results were recorded according to FIGO 2009.

After comprehensive clinical staging, patients with IA-IB1 disease were subjected to surgery. For selected patients with locally advanced cervical cancer (FIGO IB2, IIA2, and IIB), neoadjuvant chemotherapy was applied as an alternative to radiotherapy. Paclitaxel and carboplatin were intravenously administered every 3 weeks for 2–3 cycles. After reevaluating the operability after neoadjuvant chemotherapy, patients were assigned to receive surgery or radiotherapy. The details of the chemotherapy regimen and response assessment were described in our previous report (10). A written informed consent for receiving laparoscopic surgery was obtained from all patients. The surgical procedures for LRH (Querleu-Marrow type C) and systematic bilateral pelvic lymphadenectomy, adjuvant radiotherapy, and follow-up of patients have been described previously in detail (10). The Harmonic scalpel (Ethicon Endo-Surgery, Cincinnati, Ohio) is the most frequently used energy source, and most LRHs are assisted with a uterine manipulator (Karl Storz, Germany). The vaginal cuff was closed per laparoscopy. Sentinel lymph node

mapping or pelvic lymph node biopsy was not performed in these patients because of the limited histological examination capacity.

Data Collection

Clinical and pathological data were retrospectively retrieved. Age at diagnosis, FIGO stage, tumor size revealed by preoperative pelvic imaging tests, histological type of tumor, lymph node metastasis (LNM), lymph vascular space involvement (LVSI), parametrial involvement, surgical margin status and treatment procedures were recorded. The survival data were obtained from the medical records regarding follow-up examinations and yearly follow-up telephone interviews. OS was defined as the period of time from surgery to death from any cause or the date of the last follow-up, and PFS was defined as the period of time from surgery to disease progression or the date of the last follow-up.

Statistical Analysis

Survival curves were plotted by using the Kaplan-Meier method, and the intergroup differences in survival were evaluated by the log-rank test. To compare the survival rates in our laparoscopic cohort with those in the abdominal surgery arm of the LACC trial, the survival data of the LACC trial were extracted from the Kaplan-Meier curves by using GetData Graph Digitizer (version 2.25) and analyzed according to the method of Tierney JF, et al. (11). Univariate and multivariate Cox regression analyses were used to identify risk factors for PFS and OS. In the univariate analysis, all of the abovementioned clinicopathological parameters were included. The risk of survival was represented as a hazard ratio (HR) and its 95% confidential interval (CI). The significant parameters revealed by the univariate analysis were enrolled in a subsequent multivariate analysis to identify the independent risk factors. To investigate the effects of the learning curve of laparoscopy on survival in patients, the first 300 cases of LRH were divided into four groups: the 1st 50, the 2nd 50, the 2nd 100, and the 3rd 100, and the temporal survival trends were analyzed. All statistical analyses were performed per SPSS 26.0 (IBM Corp., Armonk, NY, USA) and visualized per GraphPad Prism 7.0 (GraphPad Software, Inc., San Diego, CA, USA). A P value < 0.05 was considered statistically significant.

Results

Demographic Characteristics of Patients

Between May 2008 and December 2017, 1338 patient were subjected to receive LRH, among which 22 patients failed to complete the radical surgery and converted to radiotherapy or chemoradiation. Finally, a total of 1316 women with cervical cancer undergoing LRH were included in the present study. The median age of the patients was 46 years (range, 25–76 years). The FIGO stage ranged from IA to IIB, with IB being the most frequent stage, accounting for 67.5% of the cohort. Neoadjuvant chemotherapy was administered in 232 (17.6%) patients with bulky tumors. Systematic pelvic lymphadenectomy was

performed in all 1316 patients, and additional paraaortic lymph node dissection was performed in 21 patients. Lymph node involvement was found in 18.9% of patients. After surgery, 323 (24.5%) patients underwent adjuvant radiotherapy or concomitant chemoradiation because of the presence of pathologic risk factors for recurrence. Among the 1316 patients undergoing LRH, 1114 (84.7%) were followed-up for 3 months or longer; the median follow-up period was 48 months (range, 3-144 months). The clinicopathological characteristics in the subgroup with follow-up data did not differ from those in the entire cohort (Table 1).

Table 1
Characteristics of all patients and patients with follow-up

Characteristics	All patients N= 1316 (%)	Patients with follow-up N= 1114 (%)	P- value
Age(years)			0.800
Median (range)	46 (25–76)	46 (25–76)	
Mean ± standard deviation	46.55 ± 8.37	46.65 ± 8.37	
< 45	543 (41.3)	454 (40.8)	
≥ 45	773 (58.7)	660 (59.2)	
Stage (FIGO 2009)			0.990
IA	103 (7.8)	78 (7.0)	
IB1 (≤ 2 cm)	395 (30.0)	340 (30.5)	
IB1 (> 2 cm)	365 (27.7)	317 (28.5)	
IB2	126 (9.6)	102 (9.2)	
IIA1	203 (15.4)	171 (15.4)	
IIA2	105 (8.0)	89 (8.0)	
IIB	19 (1.4)	17 (1.5)	
Primary tumor size			0.923
≤ 2.0cm	555 (42.2)	464 (41.7)	
2.1-4.0cm	527 (40.0)	455(40.8)	
> 4.0cm	234 (17.8)	195 (17.5)	
Histology			0.977
Squamous	1059 (80.5)	902 (81.0)	
Adenocarcinoma	155 (11.8)	131 (11.8)	
Adenosquamous carcinoma carcinoma	48 (3.6)	38 (3.4)	
Others	54 (4.1)	43 (3.9)	
Histologic grade			0.986
G1	121 (9.2)	107 (9.6)	

FIGO, International Federation of Gynecology and Obstetrics; LVSI, lymph vascular space invasion; RS: primary radical surgery; NACT, neoadjuvant chemotherapy

Characteristics	All patients	Patients with follow-up	<i>P</i> -value
G2	651 (49.5)	552 (49.6)	
G3	378 (28.7)	316 (28.4)	
Unknown	166 (12.6)	139 (12.5)	
Lymph node metastasis			0.433
Negative	1067 (81.1)	917 (82.3)	
Positive	249 (18.9)	197 (17.7)	
LVSI			0.776
Negative	1027 (78.0)	864 (77.6)	
Positive	289 (22.0)	250 (22.4)	
Parametrial involvement			0.909
Negative	1209 (91.9)	1022 (91.7)	
Positive	107 (8.1)	92 (8.3)	
Surgical margin			0.949
Negative	1280 (97.3)	1084 (97.3)	
Positive	36 (2.7)	30 (2.7)	
Treatment			0.747
RS	1084 (82.4)	912 (81.9)	
NACT followed by RS	232 (17.6)	202 (18.1)	
Adjuvant radiation/chemoradiation			0.665
No	975 (74.1)	840 (75.4)	
Yes	323 (24.5)	262 (23.5)	
Unknown	18 (1.4)	12 (1.1)	
FIGO, International Federation of Gynecology and Obstetrics; LVSI, lymph vascular space invasion; RS: primary radical surgery; NACT, neoadjuvant chemotherapy			

Survival After Laparoscopic Radical Hysterectomy

The stage-weighted survival rates were analyzed. Given that 2009 FIGO stage IB1 cervical cancer is divided into stage IB1 and IB2 by the tumor size with a cut-off at 2 cm according to the newly issued 2018 FIGO staging criteria (12), we stratified IB1 patients accordingly. In the patients with stage IA, IB1 (\leq

2 cm), IB1 (> 2 cm), IB2, IIA1 and IIA2-IIB tumors, the 4-year PFS rates were 98.6%, 94.5%, 87.4%, 65.6%, 80.0%, 67.4%, respectively, and the 4-year OS rates were 98.6%, 96.8%, 91.1%, 77.4%, 85.6%, 76.2%, respectively (Fig. 1A-B). These findings indicate poorer survival in patients with locally advanced disease (FIGO 2009 stage IB2, IIA2 and IIB). In contrast, the patients with 1A-IB1 tumors had excellent oncologic outcomes, with a 4-year PFS of 92.0% and a 4-year OS of 94.6%, which are comparable to PFS (HR:1.31; 95% CI, 0.59–2.93) and OS (HR:1.06; 95% CI, 0.27–4.12) in the open surgery arm of the LACC study.

Risk Factors For Survival

The multivariate Cox regression analysis following the univariate analysis revealed that advanced FIGO stage (IB2-IIB), larger tumor size (> 2 cm), histology of non-squamous cell carcinoma, LNM, LVSI were independent risk factors for OS, and advanced FIGO stage (IB2-IIB), larger tumor size (> 2 cm), histology of non-squamous cell carcinoma, LNM, LVSI and positive surgical margin were independent risk factors for PFS (Table 2). Given that the recommended standard care for locally advanced tumors is radiotherapy rather than surgery, we focused on patients with FIGO IA1-IB1 tumors, for whom surgery is preferred (13). In these patients, tumor size greater than 2 cm, non-squamous cell carcinoma, LNM, and LVSI were identified as independent risk factors for OS, and tumor size greater than 2 cm, non-squamous cell carcinoma, and LVSI were identified as independent risk factors for PFS (Table 3). The 4-year PFS and OS were as high as 96.2% and 97.5%, respectively, in patients with squamous cell carcinoma of 2 cm or smaller in diameter.

Table 2

Univariate and multivariate analysis of risk factors for OS and PFS in patients with stage IA-IIIB (N = 1114)

Variables	Univariate		Multivariate	
	HR (95%CI)	P-value	HR (95%CI)	P-value
OS				
Age (≥ 45 vs. <45 y)	1.072 (0.722–1.593)	0.730		
FIGO stage (IB2-IIIB vs. IA-IB1)	3.837 (2.567–5.737)	< 0.001	2.168 (1.409–3.337)	< 0.001
Primary tumor size (> 2 cm vs. ≤ 2 cm)	6.032 (3.302–11.020)	< 0.001	3.473 (1.820–6.625)	< 0.001
Histology (others vs. squamous)	1.981 (1.304–3.011)	0.001	2.217 (1.454–3.381)	< 0.001
Lymph node metastasis (positive vs. negative)	4.314 (2.916–6.382)	< 0.001	2.520 (1.643–3.865)	< 0.001
Parametrial involvement (positive vs. negative)	2.605 (1.524–4.452)	< 0.001	0.919 (0.508–1.662)	0.781
LVSI (positive vs. negative)	2.516 (1.683–3.760)	< 0.001	1.630 (1.044–2.545)	0.032
Surgical margin (positive vs. negative)	1.558 (0.573–4.235)	0.385		
PFS				
Age (≥ 45 vs. <45 y)	0.940 (0.689–1.283)	0.696		
FIGO stage (IB2-IIIB vs. IA-IB1)	3.804 (2.769–5.225)	< 0.001	2.359 (1.670–3.331)	< 0.001
Primary tumor size (> 2 cm vs. ≤ 2 cm)	4.306 (2.830–6.553)	< 0.001	2.619 (1.659–4.136)	< 0.001
Histology (others vs. squamous)	1.582 (1.116–2.242)	0.010	1.829 (1.285–2.602)	0.001
Lymph node metastasis (positive vs. negative)	3.081 (2.233–4.251)	< 0.001	1.824 (1.282–2.594)	0.001
Parametrial involvement (positive vs. negative)	2.493 (1.612–3.855)	< 0.001	0.963 (0.592–1.568)	0.881

HR, hazard ratio; CI, confidence interval; FIGO, International Federation of Gynecology and Obstetrics;

LVSI, lymph vascular space invasion; OS, overall survival; PFS, progression-free survival

Variables	Univariate		Multivariate	
	HR (95%CI)	<i>P</i> -value	HR (95%CI)	<i>P</i> -value
LVSI (positive vs. negative)	2.358 (1.706–3.260)	< 0.001	1.723 (1.203–2.469)	0.003
Surgical margin (positive vs. negative)	2.054 (1.009–4.182)	0.047	2.167 (1.052–4.465)	0.036
HR, hazard ratio; CI, confidence interval; FIGO, International Federation of Gynecology and Obstetrics;				
LVSI, lymph vascular space invasion; OS, overall survival; PFS, progression-free survival				

Table 3

Univariate and multivariate analysis of risk factors for OS and PFS in patients with IA-IB1 (N = 735)

Variables	Univariate		Multivariate	
	HR (95%CI)	P-value	HR (95%CI)	P-value
OS				
Age (≥ 45 vs. <45 y)	1.672 (0.855–3.270)	0.133		
FIGO stage (IB1 vs. IA)	4.902 (0.672–35.733)	0.117		
Primary tumor size (> 2 cm vs. ≤ 2 cm)	3.016 (1.522–5.979)	0.002	2.599 (1.286–5.255)	0.008
Histology (others vs. squamous)	2.941 (1.544–5.601)	0.001	3.599 (1.848–6.852)	< 0.001
Lymph node metastasis (positive vs. negative)	3.617 (1.824–7.170)	< 0.001	2.488 (1.171–5.117)	0.017
Parametrial involvement (positive vs. negative)	2.881 (1.019–8.147)	0.046	1.183 (0.381–3.675)	0.771
LVSI (positive vs. negative)	2.701 (1.376–5.303)	0.004	2.284 (1.095–4.766)	0.028
Surgical margin (positive vs. negative)	1.796 (0.246–13.093)	0.563		
PFS				
Age (≥ 45 vs. <45 y)	1.194 (0.721–1.978)	0.491		
FIGO stage (IB1 vs. IA)	8.097 (1.122–58.415)	0.038	4.121 (0.552–30.788)	0.168
Primary tumor size (> 2 cm vs. ≤ 2 cm)	2.755 (1.628–4.662)	< 0.001	2.202 (1.275–3.803)	0.005
Histology (others vs. squamous)	2.246 (1.335–3.781)	0.002	2.607 (1.534–4.430)	< 0.001
Lymph node metastasis (positive vs. negative)	2.523 (1.411–4.514)	0.002	1.739 (0.945–3.200)	0.075
Parametrial involvement (positive vs. negative)	2.128 (0.851–5.322)	0.106		

HR, hazard ratio; CI, confidence interval; FIGO, International Federation of Gynecology and Obstetrics;

LVSI, lymph vascular space invasion; OS, overall survival; PFS, progression-free survival

Variables	Univariate		Multivariate	
	HR (95%CI)	<i>P</i> -value	HR (95%CI)	<i>P</i> -value
LVSI (positive vs. negative)	2.515 (1.471-4.300)	0.001	2.205 (1.255-3.875)	0.006
Surgical margin (positive vs. negative)	1.086 (0.151-7.838)	0.934		
HR, hazard ratio; CI, confidence interval; FIGO, International Federation of Gynecology and Obstetrics;				
LVSI, lymph vascular space invasion; OS, overall survival; PFS, progression-free survival				

Learning Curve-weighted Survival

From 2008 to 2017, the yearly surgery volume of LRH increased from 32 to 209 cases (Fig. 2A). The first 300 cases were stratified according to the sequential order into 4 groups, i.e., the 1st 50 cases, the 2nd 50 cases, the 2nd 100 cases and the 3rd 100 cases. Survival analysis revealed that the 4-year OS in the 1st 50 cases was 84.0%, which was lower than that in the 2nd 50 cases (88.0%), while the OS did not significantly differ between the last 2 groups (Fig. 2B). The PFS in the 1st 50 cases was also inferior to the other 3 groups (Fig. 2C). We further analyzed the impact of the learning curve of a single surgeon on the survival of patients. The 4-year OS and PFS rates of the 1st 40 patients were both 85.0%, and improvements in OS and PFS were found after 40 cases (the 2nd - 4th 40 versus the 1st 40 cases, $HR_{OS} = 0.566$, 95% CI: 0.223-1.439; $HR_{PFS} = 0.561$, 95% CI: 0.221-1.425) (Fig. 2D-E).

Discussion

Because of the high-level evidence in favor of open surgery provided by the randomized LACC trial, the use of LRH in the treatment of cervical cancer has been questioned a lot in the past 2 years (14). In the present study, we showed that the survival outcomes are acceptable in patients with early-stage cervical cancer undergoing conventional laparoscopic surgery at our center, where the mean yearly LRH volume was 131.6 cases. In addition, the learning curve is a critical factor affecting survival, suggesting that minimally invasive surgery remains an effective treatment option for patients with early-stage cervical cancer.

Generally, the survival after LRH in patients with stage IA-IB1 cervical cancer is satisfying but varies across studies, with a 5-year PFS rate ranging from 80.2-96.3% (5, 8, 15). In the present study, we also report a high 4-year PFS of 92.0% in patients, which is not inferior to that in the open surgery group of the LACC trial. Recently emerging evidence from non-randomized studies and meta-analyses comparing survival after minimally invasive surgery versus abdominal surgery for early-stage cervical cancer remains controversial, with some results showing compromised oncologic outcomes related to minimally invasive surgery, while others did not (2, 5, 6, 16-18). However, the application of LRH for tumors of less

than 2 cm in size was supported by its non-inferior survival compared to laparotomy demonstrated by numerous studies, even by those showing increased recurrence and death risk after minimally invasive surgery (19–21). Additionally, we found that patients with < 2 cm squamous cell carcinoma, which can be identified preoperatively, had excellent survival outcomes after LRH. This subpopulation would be particularly benefit from laparoscopy with fewer morbidities, shorter hospital stays, and non-compromised survival.

It is evident that surgical proficiency is a critical determinant of oncologic outcomes after surgery. We showed a poorer OS in the first 50 cases of LRH performed in our center, which was gradually improved in successive operations and reached a plateau after 100 LRHs. In patients operated on by the same surgeon, an improvement in survival was observed after 40 LRHs, suggesting that intensive practice is required to ensure the oncologic safety of surgery. Similarly, the impact of the learning curve on the oncologic outcomes of surgery for cervical cancer has been reported in two recent studies in the wake of the LACC trial (8, 9). Moreover, the surgery volume has been identified as an independent factor for survival. In 116 surgery centers in Japan, a high surgery volume (105 cases or more within 5 years) of LRH and systematic pelvic lymphadenectomy has been identified as a significant protective factor for PFS (HR, 0.69; 95% CI, 0.57–0.84) and OS (HR, 0.75; 95% CI, 0.59–0.95) in cervical cancer patients, while a medium-low volume (less than 105 cases within 5 years) was not protective (22). A population-based retrospective cohort study from Canada identified 958 patients undergoing primary radical hysterectomy from 2006 to 2017 (475 minimally invasive procedures and 483 abdominal procedures) and showed increased recurrence and death in patients with stage IB cervical cancer after controlling for surgeon volume; however, the median cervical cancer volume in terms of radical hysterectomy (the number of hysterectomies performed in the 2 years prior to the indexed procedure) of 8 (range 4–12) appears generally low, being insufficient to definitively exclude the impact of surgeon volume on the survival outcomes (17). Generally, minimally invasive surgery demands more learning and practice than open surgery because of the complexity of the procedure, and the learning curve would be further prolonged in centers with low patient volume. Given the extremely imbalanced prevalence of cervical cancer around the world, with approximately 90% of newly diagnosed cases occurring in low-resource countries and few occurring in developed countries, and the significant disparities in laparoscopic proficiency and competence between counties, centers and surgeons, a global consensus on the surgical approach to cervical cancer seems difficult to achieve, and country- or center-based recommendations might be more meaningful.

The intraoperative assessment of tumor and lymph node potential risks and improvements for laparoscopic surgery for cervical cancer have been intensively discussed in the past two years. Laparoscopic vaginal dissection and cuff closure, the use of a uterine manipulator, and the CO₂ pneumoperitoneum are considered to be processes potentially causing nosocomial dissemination of cervical cancer cells (23, 24). All these were used in the patients we studied. Several studies have provided retrospective evidence supporting some improvements in LRH to prevent possible tumor cell spillage. The survival after LRH with the “no-look no-touch technique” for stage IB1 tumors was found to be equal to that after open surgery (15). A multicenter analysis of 389 patients showed that LRH with

transvaginal closure of the vaginal cuff avoided the use of a manipulator and offered oncologic outcomes similar to those of the laparotomy arm in the LACC trial (25). The use of a surgical stapler is also an option for vaginal closure to avoid tumor cell spillage (26). The potential benefits regarding oncologic safety of these adjustments need to be tested in randomized controlled trials.

Despite the relatively large number of patients involved, the limitations associated with the single-center, retrospective study design of the present study, such as selection bias and confounding bias, cannot be ignored. The missing data in the long-term follow-up of patients represents a major issue. Unfortunately, the median follow-up time was only 48 months, making an accurate estimation of the 5-year survival rate difficult. In addition, approximately 15% of patients were lost to follow-up, which might lead to some bias in the survival analysis. Further studies with long-term follow-up are needed to further clarify the oncologic outcomes after LRH in patients with early-stage cervical cancer.

Conclusions

In conclusion, favorable oncologic outcomes can be achieved in patients with IA-IB1 cervical cancer after LRH in a center with a high surgery volume. Surgical experience is an essential factor that needs to be considered in any future randomized trials comparing minimally invasive surgery to open surgery for cervical cancer.

Abbreviations

Laparoscopic radical hysterectomy, LRH

Overall survival, OS

Progression-free survival, PFS

the Laparoscopy Approach to Cervical Cancer, LACC

Magnetic resonance imaging, MRI

Computed tomography, CT

Positron emission tomography, PET

Lymph node metastasis, LNM

Lymph vascular space involvement, LVSI

Hazard ratio, HR

Confidential interval, CI

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Tongji Medical College, Huazhong University of Science and Technology (No. 2020S246).

Consent for publication

Not applicable

Availability of data and materials

The data used to support the findings of this study are available from the corresponding author upon request.

Competing interests

The authors declare no conflicts of interests in this work.

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Authors' contributions

Conception & Design of Study: JC, ZHW

Data Collection: YHH, WHD, YZ, ZHW

Data Analysis & Interpretation :YHH, JC, SHW

Responsible Surgeon : HBW, WHD, YZ, SHW, XQH, JFG, SHY, ZHW Statistical Analysis: YHH, JC, XQH, SHY

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Figures

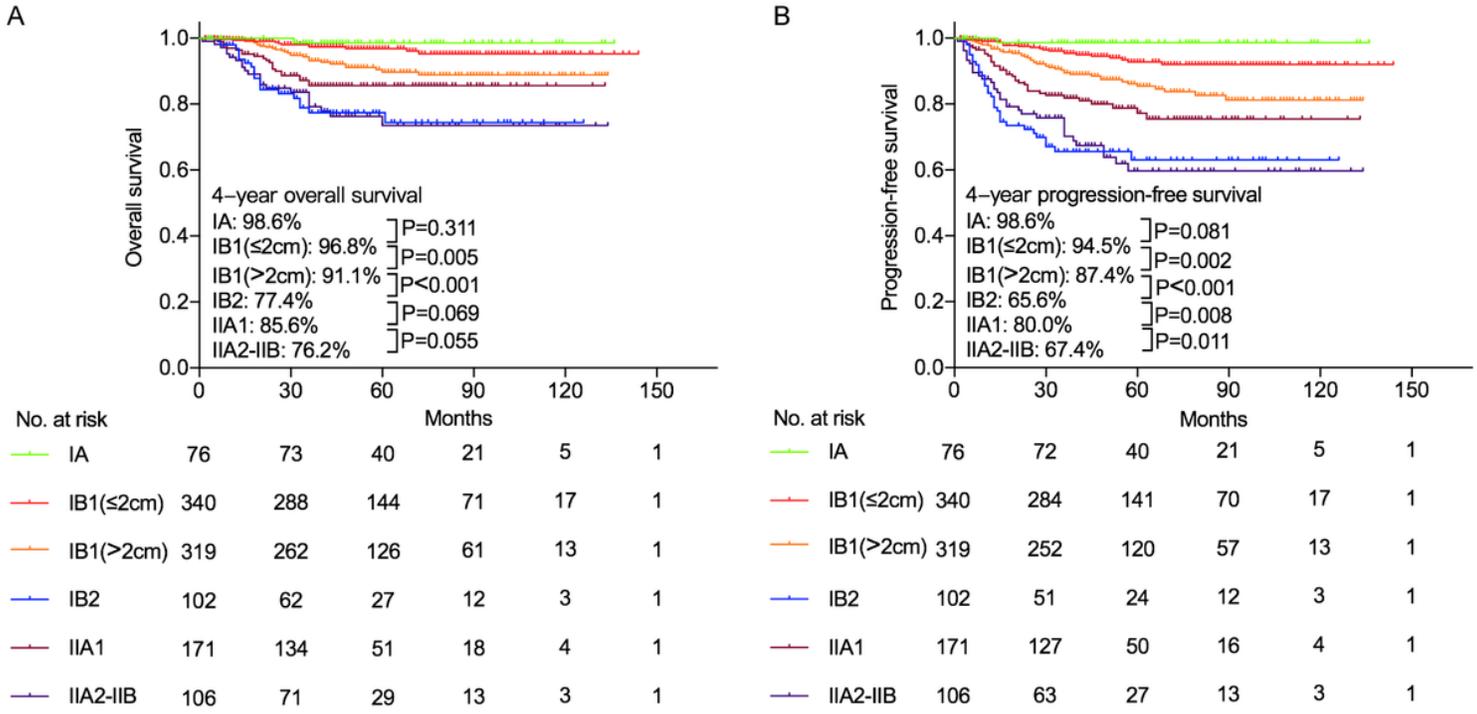


Figure 1

Survival analysis of patients with stage IA-IIB. (A) Overall survival of patient with IA-IIB (B) Progression-free survival of patients with IA-IIB.

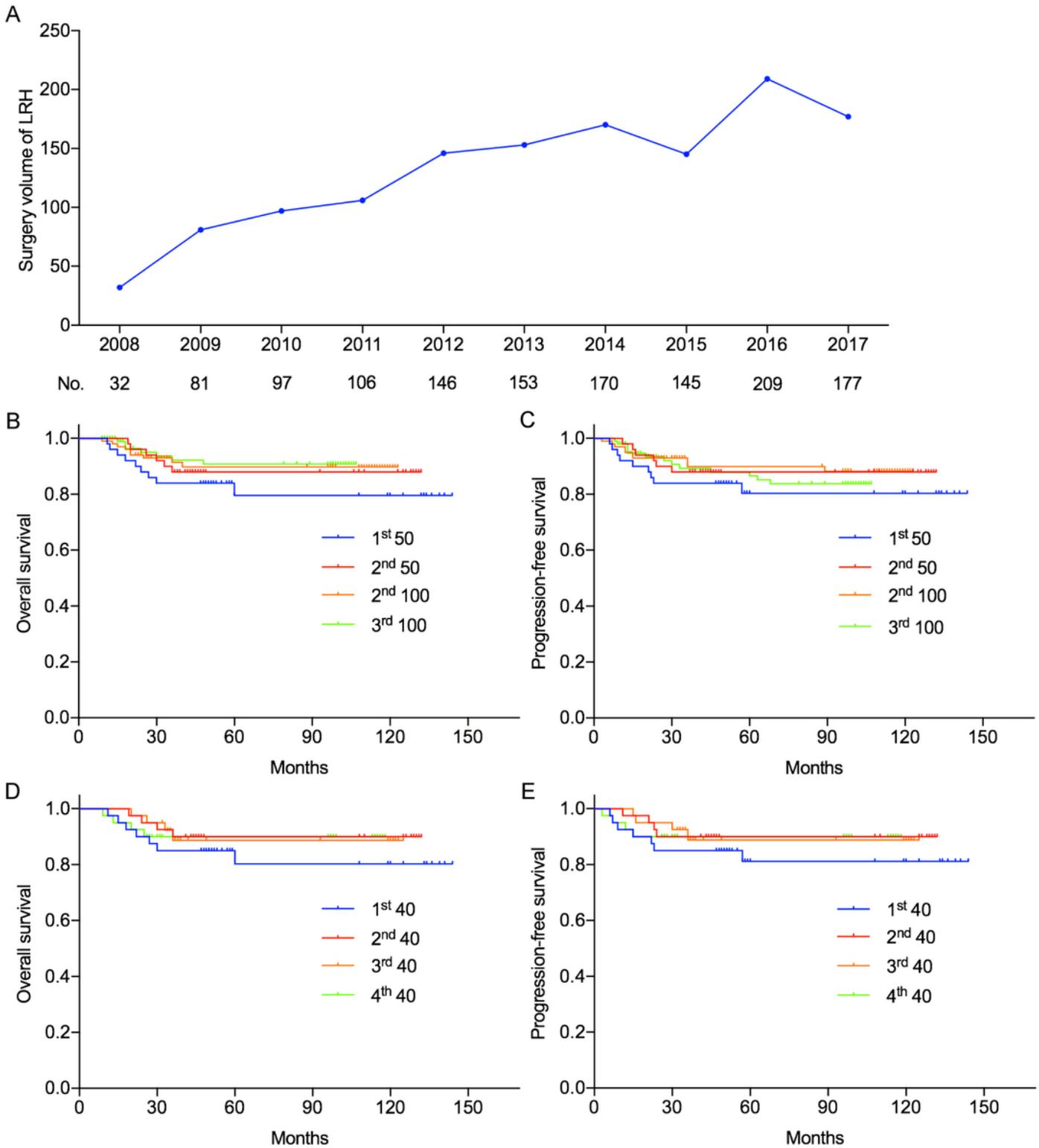


Figure 2

Learning Curve-weighted Survival. (A) Yearly surgery volume of laparoscopic radical hysterectomy, LRH; (B) Overall survival of consecutive cases in center; (C) Progression-free survival of consecutive cases in center; (D) Overall survival of consecutive cases by one surgeon; (E) Progression-free survival of consecutive cases by one surgeon.