

Review

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Minimally invasive vs. open surgery: comparison of surgical complications in radical hysterectomy for cervical cancer

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Abstract

Cervical cancer remains a significant global health concern, ranking as the third most prevalent malignancy and the second leading cause of cancer-related mortality among women in the United States. Early-stage cervical cancer is typically managed with radical hysterectomy, traditionally performed via open abdominal or vaginal approaches. Minimally invasive radical hysterectomy (MIS-RH) was introduced in 1993, yet findings from the laparoscopic approach to cervical cancer (LACC) trial have raised substantial concerns regarding the oncologic safety of the laparoscopic approach. As a result, abdominal radical hysterectomy (ARH) has been reaffirmed as the standard of care in surgical practice for cervical cancer. Despite this shift, some studies suggest that minimally invasive surgery (MIS), specifically laparoscopic radical hysterectomy (LRH), may be associated with fewer perioperative complications compared to open surgery. However, other studies report no significant differences in complication rates when comparing LRH to ARH. Persistent challenges in adopting MIS for cervical cancer treatment include the



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complexity of these procedures, extended learning curves, and increased costs. This narrative review provides a comprehensive comparison of LRH and ARH complications, offering insights into their safety, efficacy, and overall benefits to advance the ongoing discussion on optimal surgical approaches for cervical cancer treatment.

Keywords: Cervical cancer, surgical complication, minimally invasive surgery

INTRODUCTION

Cervical cancer remains a critical global health concern, ranking as the third most prevalent cancer and the second leading cause of cancer-related mortality among women in the United States^[1]. Its incidence and mortality rates vary significantly worldwide, with higher prevalence and mortality observed in developing nations^[2,3]. Cervical cancer is categorized into early and advanced stages, with surgical intervention being essential for early-stage cases to enhance patient survival^[4,5]. Radical hysterectomy, often performed alongside pelvic lymphadenectomy, is a standard procedure for treating early-stage cervical cancer, yielding a five-year survival rate of up to 87% in appropriately selected patients^[6,7]. Traditionally, radical hysterectomy has been conducted through open abdominal or vaginal methods. Since the introduction of laparoscopic radical hysterectomy (LRH) in 1993, minimally invasive techniques, including both laparoscopic and robotic-assisted methods, have become available in gynecological surgery^[8]. These approaches provide several advantages over traditional open surgery, such as decreased blood loss, shorter hospital stays, quicker recovery times, and reduced postoperative pain^[9,10]. Nonetheless, despite these benefits, the adoption of minimally invasive techniques in gynecologic oncology has been slower compared to other surgical fields due to concerns about potential cancer dissemination risks^[11]. Implementing the laparoscopic approach had been adopted and integrated into clinical practice until the publication of findings from the laparoscopic approach to cervical cancer (LACC) trial^[12]. This landmark study raised concerns about the safety and efficacy of minimally invasive surgery (MIS) for radical hysterectomy showing that LRH was associated with lower disease-free survival and overall survival rates compared to abdominal radical hysterectomy (ARH). These unexpected results led to significant changes in clinical guidelines^[13]. The National Comprehensive Cancer Network (NCCN) and the European Society of Gynaecological Oncology (ESGO) subsequently updated their guidelines to recommend open ARH as the standard surgical strategy for managing early-stage cervical cancer^[14,15]. Despite these guideline changes, the debate over the optimal surgical approach continues. Many retrospective and non-randomized studies have shown that laparoscopic techniques may have fewer perioperative complications than open surgery, including significant morbidity such as bladder dysfunction, blood loss, and complications related to blood transfusions^[16,17]. In contrast, some studies suggested no significant difference in intraoperative and postoperative complications between LRH and ARH^[18]. The complexity of MIS procedures, longer learning curves, and higher costs represent unresolved challenges and fields of debate. Robotic-assisted surgeries, for instance, offer enhanced three-dimensional visualization and precise surgical positioning, but these benefits must be weighed against the associated costs and learning requirements^[18,19]. Given the conflicting evidence and ongoing debate, it is essential to critically evaluate the complications and risks associated with different surgical approaches to radical hysterectomy. This narrative review aims to provide a comprehensive comparison of the complications of LRH and ARH, excluding robotic-assisted techniques. By synthesizing the latest evidence, this review will contribute to the ongoing discussion on the safety, efficacy, and overall benefits of these surgical approaches in the management of early-stage cervical cancer.

METHODS

Literature search

A comprehensive search of electronic databases, including PubMed, MEDLINE, Embase, and the Cochrane Library, was conducted to identify relevant studies published from January 1990 to April 2024. Search terms

included combinations of keywords such as “cervical cancer”, “radical hysterectomy”, “laparoscopic surgery”, “open surgery”, “minimally invasive surgery”, “complications”, “perioperative outcomes”, “survival rates”, and “postoperative morbidity”. Additionally, the reference lists of selected articles and pertinent review papers were manually screened to capture any further relevant studies.

Inclusion and exclusion criteria

Studies were included in this review if they met the following criteria: the study population comprised patients diagnosed with early-stage cervical cancer; the intervention involved LRH or ARH. The study reported on complications and perioperative outcomes; the full text of the article was available in English. Exclusion criteria were: studies involving robotic-assisted radical hysterectomy; studies focused solely on advanced-stage cervical cancer or other gynecological cancers, editorials, letters, and case reports.

Data synthesis and analysis

The extracted data were synthesized narratively, focusing on comparing the rates and types of complications between LRH and ARH. The review analyzed the role of surgeon experience, intraoperative complications, and postoperative complications. We performed a qualitative synthesis, organized in thematic sections, to summarize the available evidence.

RESULTS

LRH has been developed as a treatment for gynecologic cancers and has gradually been recognized as significant in the management of early cervical cancer because of its operative safety^[20]. Laparoscopic surgery offers several benefits compared to open surgery, including reduced postoperative pain, shorter hospital stays, improved cosmetic outcomes, faster recovery, and quicker return of bowel function^[8]. Even before the publication of the LACC trial, the widespread adoption of LRH by gynecologic oncologists represented a real challenge due to its technical complexity, extended learning curve, and concerns regarding surgical morbidity compared to ARH^[18,21,22]. Intraoperative and postoperative complications may lead to substantial personal, financial, and social costs^[23].

Surgeon experience

There is a correlation between surgical performance and perioperative outcomes^[7]. Specifically, for open surgery in cervical cancer, institutions with extensive surgical experience show better oncologic outcomes and reduced perioperative complications compared to those with limited experience^[24]. The impact of the learning curve in LRH including aspects of surgical quality, may have contributed to poor outcomes observed in the LACC trial^[7]. Notably, the LACC trial found complication rates between the MIS group and the open surgery group were sometimes discordant with other authors^[12]. However, the effect of the learning curve in a minimally invasive approach was not assessed in the trial. The LACC trial protocol required LRH quality control through the evaluation of an unedited surgical video, but this video was not available, making the evaluation process unclear^[12]. Surgeon proficiency may be a critical factor in determining complication rates, but unfortunately, this data is not frequently investigated in the literature, further complicating the interpretation of the available data^[24]. Even in the meta-analysis by Zhang *et al.*, which included only randomized controlled trials (RCTs), it was not possible to perform a pooled analysis regarding the learning curve, surgical proficiency, and outcomes based on the surgeon's experience, as these data were not reported^[25,26]. A retrospective analysis conducted by Kim *et al.*, involving 89 patients with early-stage cervical cancer undergoing radical hysterectomy via open, laparoscopic, or robotic-assisted approaches, emphasized the importance of surgical learning curves for each technique^[27]. The findings indicated that the threshold number of cases required to attain improved surgical proficiency was 16 for ARH, 13 for LRH, and 21 for robotic-assisted radical hysterectomy. The authors concluded that achieving surgical expertise is a critical factor influencing the outcomes of minimally invasive procedures^[27]. Similarly,

Chong *et al.* reported that patients treated later in the surgeon's learning curve demonstrated a reduction in complication rates and improved overall clinical outcomes^[28].

Addressing the issue of surgeon experience requires a multifaceted approach, including standardized training programs, certification processes, and mentorship during the early phases of the learning curve. Centralizing the treatment of cervical cancer in high-volume centers is a particularly effective strategy, as it ensures that a limited number of surgeons, who are highly skilled in radical hysterectomy, perform these procedures regularly. This not only enhances surgical proficiency but also leads to improved perioperative and oncologic outcomes by concentrating expertise and maintaining high-quality care standards.

Intraoperative complications

In most studies and pooled analyses, intraoperative complications included vascular, bladder, urethral, and nerve injuries, along with conversion to open surgery. Meta-analyses have reported rates of intraoperative complications ranging from 5.1% to 7.1%^[18,20,23,25]. In contrast, the LACC trial reported an incidence of 11%^[12], while the SUCCOR study reported 9.3%^[29]. Both the SUCCOR study and the LACC trial found no significant differences in the overall incidence of intraoperative complications when compared to LRH with the open approach. An Italian retrospective study investigating cases of surgically treated cervical cancer before the publication of the LACC trial did not find significant differences in intraoperative complications^[30]. Additionally, Kampers *et al.* found no overall significant difference between the two investigated groups. This finding was also confirmed in the RCT sub-analysis. However, the retrospective subgroup analysis showed lower intraoperative morbidity in the LRH group^[31].

A meta-analysis conducted by Li *et al.* found that the LRH group exhibited a greater incidence of complications, including cystotomy, bowel injury, and subcutaneous emphysema, compared to ARH^[32]. Earlier studies have identified the use of a Veress needle or trocar as the primary cause of intestinal injuries during laparoscopic procedures^[33,34]. Additionally, factors such as elevated intra-abdominal pressure, higher gas flow rates, and increased total gas volume have been implicated as contributors to the risk of subcutaneous emphysema in LRH^[35].

Using surgical instruments was linked to visceral injuries, which could result from thermal damage caused by the high temperature of the equipment, affecting the submucosal or deeper tissues of the bladder, bowels, and gut^[28,36]. Previous studies have assessed the risk of thermal injury to the bowel during laparoscopic procedures. It is important to acknowledge that thermal injury is an inherent risk of the laparoscopic technique during radical hysterectomy, and surgeons should know this issue. No post-LACC studies evaluated prospectively intraoperative complications, which ideally should be investigated in future studies^[37].

Before the LACC trial, many pooled analyses showed that MIS is associated with less estimated blood loss, shorter hospital stays, and longer surgical durations compared to open surgery, which is consistent with the results from the LACC trial and the SUCCOR study^[12,20,23,29]. Corrado *et al.* reported that LRH is superior to ARH in terms of lower estimated blood loss, transfusion rates, and shorter hospital stays^[38]. A recent retrospective study by Pecorino *et al.* found that the operative time for LRH was significantly longer than for ARH. However, this longer duration is balanced by the significantly lower intraoperative estimated blood loss in the minimally invasive group, thus confirming previous findings^[30]. Kampers *et al.* analyzed the results of over 20 studies and quantified the mean difference in estimated blood loss in 114.34 mL^[31]. Recently, Zhang *et al.* conducted a meta-analysis that included only RCTs. In the pooled analysis of ten studies, they showed that blood loss was significantly lower in the laparoscopic group, which consistently

reported a longer operative time across all the studies considered^[25]. The results regarding the duration of surgery are in contrast with the findings of Kampers *et al.*, who did not report any significant difference between the minimally invasive and open technique^[31].

Radical hysterectomy necessitates thorough dissection of the ureteral adventitial tissue to identify the ureter's course and pinpoint the location of the uterine artery. Ureteral injuries frequently arise during the dissection of the distal ureter, particularly at its junction with the bladder, which represents the most technically demanding part of the procedure^[23]. Similarly, bladder injuries may occur during its dissection to obtain an adequate vaginal resection margin, which can heighten the likelihood of intraoperative urological complications^[23].

Previous comparative studies have shown no statistically significant difference in urologic complications between LRH and ARH. Steed *et al.* focused on urological complications, ARH, and vaginal-assisted LRH, reporting a higher intraoperative complication rate in the laparoscopic group^[39]. The meta-analysis by Hwang *et al.* confirmed the findings of most previous studies, showing no significant difference in urological complications between the two surgical approaches. They also reported that the risk of bladder intraoperative complications is statistically higher than that of ureteral injuries, particularly in overweight patients^[23].

Postoperative complication

The reported rates of postoperative complications in meta-analyses range from 10.1% to 25.4%^[25,31,32,37,40], whereas the LACC trial reported a 42% incidence and the SUCCOR study reported 21.5%^[12,29]. The prospective design of the LACC trial likely contributed to a more comprehensive assessment of variables, resulting in higher reported incidences. Retrospective studies, such as the SUCCOR study, may under-report complications because of incomplete data collection.

Studies conducted before the LACC trial generally concluded that patients undergoing open surgery experienced a higher rate of postoperative complications compared to those undergoing minimally invasive procedures^[23,28,41]. Li *et al.* reported that LRH offered advantages over ARH in reducing complications such as wound and pelvic infections, abscesses, lymphedema, intestinal obstruction, pulmonary embolism, and urinary tract infections, although it presented a higher risk of fistula formation^[32]. Similarly, the LACC trial identified statistically significant differences in postoperative outcomes, noting an increased frequency of cardiac events and surgical wound complications in the open surgery group^[12]. The SUCCOR study also observed a higher incidence of wound complications and bladder dysfunction in patients undergoing open surgery, while ureteral fistulas were less common compared to those in the LRH group^[29]. Furthermore, a retrospective study by Kim *et al.*, involving 6,235 patients who underwent ARH and 3,100 treated with LRH, demonstrated that the laparoscopic approach was associated with fewer postoperative complications and shorter hospital stays in individuals with early-stage cervical cancer^[27].

Other postoperative complications occurring 30 days after ARH include sensory-motor deficits (70%-80%), sexual dysfunction, and radical dysfunction^[42]. Studies comparing the effects of sexual dysfunction and pelvic floor dysfunctions between laparoscopic and ARH have found no significant differences, suggesting that the procedure itself, rather than the surgical approach, significantly affects sexual activity^[42,43]. However, the magnified view and precise manipulation possible with laparoscopic surgery may facilitate nerve dissection and provide more accurate surgical procedures, potentially reducing the rate of neural damage^[43]. Marchand *et al.*, combining data from 12,673 patients across 29 studies, found a significantly lower risk of blood transfusion in the LRH group, with an overall odds ratio of 0.28. However, no difference in

intraoperative or postoperative mortality (within 90 days after the surgical procedure) was observed^[44].

Wang *et al.* reported a higher incidence of surgical wound infections associated with the open surgical approach^[40]. Additionally, Yun *et al.* analyzed infection risks related to different surgical techniques and found that MIS is linked to a lower risk of wound infections and a reduced overall incidence of postoperative complications. However, no difference was noted in the incidence of pelvic abscesses^[37]. These results are consistent with the findings reported in both the LACC trial and the SUCCOR study.

From a surgical standpoint, laparoscopy minimizes peritoneal trauma, which reduces the likelihood of postoperative adhesions between the anterior abdominal wall and intraperitoneal structures. This reduction is particularly advantageous for patients requiring adjuvant radiotherapy, as it can lower the associated toxicity. This consideration is critical because the open surgical approach is recognized as a significant predictor of morbidity in patients undergoing radical hysterectomy followed by adjuvant radiotherapy^[25,33,34].

Reducing complications also involves tailoring surgical interventions to optimize outcomes and minimize postoperative morbidity. The SHAPE trial demonstrated that, in patients with low-risk cervical cancer, simple hysterectomy was equally effective as radical hysterectomy in preventing pelvic recurrence over three years while significantly lowering the risk of urinary complications, such as incontinence and retention^[45].

CONCLUSION

The results of the LACC trial led to a shift towards the open approach because of oncologic outcomes and the detrimental effect of MIS on survival outcomes. Currently, international guidelines recommend the open approach as the standard option. However, analyses of intraoperative complications have shown no differences in risk rates between the two techniques, showing that the minimally invasive approach is a safe choice in terms of surgical morbidity. Additionally, LRH has shown advantages such as lower blood loss, reduced length of stay, and a lower risk of postoperative complications and wound infections. The principal strength of this study is its comprehensive analysis of data collected from a wide range of high-quality studies, providing valuable insights into the safety and efficacy profiles of both surgical approaches. Furthermore, its focus on surgical complications as the primary outcome offers a clear and clinically significant perspective for guiding surgical decision-making. However, despite its comprehensive scope, this review is inherently constrained by the variability in study designs and methodologies among the included literature, which may introduce heterogeneity into the findings. Many of the cited studies are retrospective or non-randomized, potentially limiting the strength of the evidence due to biases and confounding factors. Additionally, differences in surgeon expertise and institutional practices across the studies reviewed could influence the reported complication rates, thereby affecting the generalizability of the conclusions. Considering these findings, if ongoing prospective trials show the non-inferiority of LRH compared to ARH in terms of survival and oncological outcomes, the role of MIS could be reconsidered.

DECLARATIONS

Authors' contributions

Conception and design of the study: Ferrari FA, Giannini A, Pecorino B, Cuccu I, Gozzini E, Majd HS, Barra F, Ferrari F

Material preparation, data collection, and analysis: Ferrari FA, Cuccu I, Barra F

The first draft of the manuscript: Ferrari FA, Ferrari F, Giannini A

Manuscript revision and validation: Ferrari F, Giannini A, Pecorino B, Majd HS, Gozzini E

All authors read and approved the final manuscript.

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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REFERENCES

1. Wolf J, Wu Y, Hayek J, Zhang Q, Alagkiozidis I. Trends in early-stage cervical cancer management in the US: a national cancer database analysis. *Curr Oncol* 2024;31:2836-45. [DOI](#) [PubMed](#) [PMC](#)
2. Arbyn M, Weiderpass E, Bruni L, et al. Estimates of incidence and mortality of cervical cancer in 2018: a worldwide analysis. *Lancet Glob Health* 2020;8:e191-203. [DOI](#) [PubMed](#) [PMC](#)
3. Ferrari FA, Magni F, Bosco M, et al. The role of micronutrients in human papillomavirus infection, cervical dysplasia, and neoplasm. *Healthcare* 2023;11:1652. [DOI](#) [PubMed](#) [PMC](#)
4. Van Damme A, Tummers P, De Visschere P, et al. Exclusion of non-Involved uterus from the target volume (EXIT-trial): an individualized treatment for locally advanced cervical cancer using modern radiotherapy and imaging techniques followed by completion surgery. *Clin Transl Radiat Oncol* 2024;47:100793. [DOI](#) [PubMed](#) [PMC](#)
5. Giannini A, D'Oria O, Chiantera V, et al. Minimally invasive surgery for cervical cancer: should we look beyond squamous cell carcinoma? *J Invest Surg* 2022;35:1602-3. [DOI](#)
6. Michalas S, Rodolakis A, Voulgaris Z, Vlachos G, Giannakoulis N, Diakomanolis E. Management of early-stage cervical carcinoma by modified (Type II) radical hysterectomy. *Gynecol Oncol* 2002;85:415-22. [DOI](#) [PubMed](#)
7. Vázquez-Vicente D, Boria F, Castellanos T, et al; SUCCOR Study Group. SUCCOR morbidity: complications in minimally invasive versus open radical hysterectomy in early cervical cancer. *Int J Gynecol Cancer* 2024;34:203-8. [DOI](#) [PubMed](#)
8. Kennedy AW, Peterson G, Tuason LJ, Belinson JL, Webster KD. Radical hysterectomy for cervical cancer: the effect of shorter length of stay on outcome. *Cleve Clin J Med* 1995;62:193-7. [DOI](#) [PubMed](#)
9. Sevin B, Method MW, Nadji M, Lu Y, Averette HA. Efficacy of radical hysterectomy as treatment for patients with small cell carcinoma of the cervix. *Cancer* 1996;77:1489-93. [DOI](#) [PubMed](#)
10. Ferrari FA, Crestani B, Torroni L, et al. Wound infiltration with local anesthetics versus transversus abdominis plane block for postoperative pain management in gynecological surgery: a systematic review and meta-analysis of randomized controlled trials. *J Minim Invasive Gynecol* 2024;S1553-4650(24)01505-X. [DOI](#) [PubMed](#)
11. Kay AH, Levy R, Hills N, et al. Evidence-based prescribing of opioids after laparotomy: a quality-improvement initiative in gynecologic oncology. *Gynecol Oncol Rep* 2024;53:101396. [DOI](#) [PubMed](#) [PMC](#)
12. Ramirez PT, Frumovitz M, Pareja R, et al. Minimally invasive versus abdominal radical hysterectomy for cervical cancer. *N Engl J Med* 2018;379:1895-904. [DOI](#)
13. Bizzarri N, Obermair A, Hsu HC, et al. Consensus on surgical technique for sentinel lymph node dissection in cervical cancer. *Int J Gynecol Cancer* 2024;34:504-9. [DOI](#) [PubMed](#)
14. Abu-Rustum NR, Yashar CM, Arend R, et al. NCCN guidelines® insights: cervical cancer, version 1.2024. *J Natl Compr Canc Netw* 2023;21:1224-33. [DOI](#) [PubMed](#)
15. Cibula D, Raspollini MR, Planchamp F, et al. ESGO/ESTRO/ESP Guidelines for the management of patients with cervical cancer - Update 2023. *Int J Gynecol Cancer* 2023;33:649-66. [DOI](#) [PubMed](#) [PMC](#)
16. Ceccaroni M, Roviglione G, Farulla A, et al. Minimally invasive treatment of diaphragmatic endometriosis: a 15-year single referral center's experience on 215 patients. *Surg Endosc* 2021;35:6807-17. [DOI](#)
17. Ghezzi F, Fanfani F, Malzoni M, et al. Minilaparoscopic radical hysterectomy for cervical cancer: multi-institutional experience in comparison with conventional laparoscopy. *Eur J Surg Oncol* 2013;39:1094-100. [DOI](#)

18. Marchand G, Masoud AT, Abdelsattar A, et al. Meta-analysis of laparoscopic radical hysterectomy, excluding robotic assisted versus open radical hysterectomy for early stage cervical cancer. *Sci Rep* 2023;13:273. DOI PubMed PMC
19. Akdemir A, Zeybek B, Ozgurel B, Oztekin MK, Sendag F. Learning curve analysis of intracorporeal cuff suturing during robotic single-site total hysterectomy. *J Minim Invasive Gynecol* 2015;22:384-9. DOI PubMed
20. Bogani G, Borghi C, Leone Roberti Maggiore U, et al. Minimally invasive surgical staging in early-stage ovarian carcinoma: a systematic review and meta-analysis. *J Minim Invasive Gynecol* 2017;24:552-62. DOI
21. Majd H, Ferrari F, Gubbala K, Campanile RG, Tozzi R. Latest developments and techniques in gynaecological oncology surgery. *Curr Opin Obstet Gynecol* 2015;27:291-6. DOI PubMed
22. Guerrisi R, Smyth SL, Ismail L, Horne A, Ferrari F, Soleymani Majd H. Approach to radical hysterectomy for cervical cancer in pregnancy: surgical pathway and ethical considerations. *J Clin Med* 2022;11:7352. DOI PubMed PMC
23. Hwang JH. Urologic complication in laparoscopic radical hysterectomy: meta-analysis of 20 studies. *Eur J Cancer* 2012;48:3177-85. DOI PubMed
24. Matsuo K, Shimada M, Yamaguchi S, et al. Association of radical hysterectomy surgical volume and survival for early-stage cervical cancer. *Obstet Gynecol* 2019;133:1086-98. DOI PubMed PMC
25. Zhang F, Song X. Laparoscopic versus abdominal radical hysterectomy for cervical cancer: a meta-analysis of randomized controlled trials. *Am J Clin Oncol* 2022;45:465-74. DOI PubMed PMC
26. Ferrandina G, Corrado G, Scambia G. Minimally invasive surgery and quality of life in cervical cancer. *Lancet Oncol* 2020;21:746-8. DOI PubMed
27. Kim S, Min KJ, Lee S, et al. Learning curve could affect oncologic outcome of minimally invasive radical hysterectomy for cervical cancer. *Asian J Surg* 2021;44:174-80. DOI
28. Chong GO, Park NY, Hong DG, Cho YL, Park IS, Lee YS. Learning curve of laparoscopic radical hysterectomy with pelvic and/or para-aortic lymphadenectomy in the early and locally advanced cervical cancer: comparison of the first 50 and second 50 cases. *Int J Gynecol Cancer* 2009;19:1459-64. DOI PubMed
29. Chiva L, Zanagnolo V, Querleu D, et al; SUCCOR study Group. SUCCOR study: an international European cohort observational study comparing minimally invasive surgery versus open abdominal radical hysterectomy in patients with stage IB1 cervical cancer. *Int J Gynecol Cancer* 2020;30:1269-77. DOI
30. Pecorino B, D'Agate MG, Scibilia G, et al. Evaluation of surgical outcomes of abdominal radical hysterectomy and total laparoscopic radical hysterectomy for cervical cancer: a retrospective analysis of data collected before the LACC trial. *Int J Environ Res Public Health* 2022;19:13176. DOI PubMed PMC
31. Kampers J, Gerhardt E, Sibbertsen P, et al. Perioperative morbidity of different operative approaches in early cervical carcinoma: a systematic review and meta-analysis comparing minimally invasive versus open radical hysterectomy. *Arch Gynecol Obstet* 2022;306:295-314. DOI PubMed PMC
32. Li Y, Kong Q, Wei H, Wang Y. Comparison of the complications between minimally invasive surgery and open surgical treatments for early-stage cervical cancer: a systematic review and meta-analysis. *PLoS One* 2021;16:e0253143. DOI PubMed PMC
33. der Voort M, Heijnsdijk EA, Gouma DJ. Bowel injury as a complication of laparoscopy. *Br J Surg* 2004;91:1253-8. DOI PubMed
34. Llarena NC, Shah AB, Milad MP. Bowel injury in gynecologic laparoscopy: a systematic review. *Obstet Gynecol* 2015;125:1407-17. DOI PubMed
35. Ott DE. Subcutaneous emphysema - beyond the pneumoperitoneum. *JSLs* 2014;18:1-7. DOI PubMed PMC
36. Zorzato PC, Ferrari FA, Garzon S, et al. Advanced bipolar vessel sealing devices vs conventional bipolar energy in minimally invasive hysterectomy: a systematic review and meta-analysis. *Arch Gynecol Obstet* 2024;309:1165-74. DOI PubMed PMC
37. Yun Z, Li X, Zhu D, Li L, Jiang S. A meta-analysis examining the impact of open surgical therapy versus minimally invasive surgery on wound infection in females with cervical cancer. *Int Wound J* 2024;21:e14535. DOI PubMed PMC
38. Corrado G, Anchora LP, Bruni S, et al. Patterns of recurrence in FIGO stage IB1-IB2 cervical cancer: comparison between minimally invasive and abdominal radical hysterectomy. *Eur J Surg Oncol* 2023;49:107047. DOI
39. Steed H, Rosen B, Murphy J, Laframboise S, De Petrillo D, Covens A. A comparison of laparoscopic-assisted radical vaginal hysterectomy and radical abdominal hysterectomy in the treatment of cervical cancer. *Gynecol Oncol* 2004;93:588-93. DOI PubMed
40. Wang H, Li D, Wang C, et al. Efficacy evaluation of vaginal-assisted laparoscopic radical hysterectomy and laparoscopic radical hysterectomy for cervical cancer: a single-center retrospective case series study. *Ann Transl Med* 2022;10:124. DOI PubMed PMC
41. Nam JH, Park JY, Kim DY, Kim JH, Kim YM, Kim YT. Laparoscopic versus open radical hysterectomy in early-stage cervical cancer: long-term survival outcomes in a matched cohort study. *Ann Oncol* 2012;23:903-11. DOI
42. Xiao M, Gao H, Bai H, Zhang Z. Quality of life and sexuality in disease-free survivors of cervical cancer after radical hysterectomy alone: a comparison between total laparoscopy and laparotomy. *Medicine* 2016;95:e4787. DOI PubMed PMC
43. Bogani G, Serati M, Nappi R, Cromi A, di Naro E, Ghezzi F. Nerve-sparing approach reduces sexual dysfunction in patients undergoing laparoscopic radical hysterectomy. *J Sex Med* 2014;11:3012-20. DOI PubMed
44. Marchand G, Taher Masoud A, Abdelsattar A, et al. Systematic review and meta-analysis of laparoscopic radical hysterectomy vs. robotic assisted radical hysterectomy for early stage cervical cancer. *Eur J Obstet Gynecol Reprod Biol* 2023;289:190-202. DOI
45. Nistor SI, El Tawab S, Zouridis A, Ferrari F, Soleymani Majd H. Minimally invasive surgery in the management of early stage cervical cancer after the publication of SHAPE trial. *Int J Gynecol Cancer* 2024;34:1115. DOI PubMed