Research Article

Perioperative and Survival Outcomes of Robotic-Assisted Surgery, Comparison with Laparoscopy and Laparotomy, for Ovarian Cancer: A Network Meta-Analysis

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Objective. We aimed to compare the perioperative and survival outcomes of robotic-assisted surgery, traditional laparoscopy, and laparotomy approaches in ovarian cancer.

Methods. PubMed, Cochrane Library, Embase, Web of Science, and Chinese National Knowledge Infrastructure (CNKI) were searched using multiple terms for ovarian cancer surgeries, including comparative studies in Chinese and English. Literatures are published before August 31, 2021. The outcomes include operating time, estimated blood loss, length of hospital stay, postoperative/intraoperative/total complications, pelvic/para-aortic/total lymph nodes, transfusion, and five-year overall survival rate. The dichotomous data, continuous data, and OS data were pooled and reported as relative risk, standardized mean differences, and hazard ratio HRs with 95% confidence intervals, respectively. The Newcastle–Ottawa Scale was used to evaluate the risk of bias of included studies. Results. Thirty-eight studies, including 8,367 patients and three different surgical approaches (robotic-assisted laparoscopy surgery, traditional laparoscopy, or laparotomy approaches), were included in this network meta-analysis. Our analysis shows that the operating time of laparotomy was shorter than laparoscopy. The robotic-assisted laparoscopy has the least estimated blood loss during the surgery, followed by laparoscopy, and finally laparotomy. Compared with laparotomy, the incidence of blood transfusion was lower in the robotic-assisted laparoscopy and laparoscopy groups, and the length of hospital stay is shorter. Laparotomy had a significantly higher incidence of total complications than robotic-assisted laparoscopy and laparoscopy and higher postoperative complications than laparoscopy. For the number of pelvic/para-aortic/total lymph nodes removed by different surgical approaches, our analysis revealed no statistical difference. Our analysis also revealed no significant differences in intraoperative complications and 5-year OS among the three surgical approaches. Conclusion. Compared with laparotomy, robotic-assisted laparoscopy and laparoscopy had a shorter hospital stay, decreased blood loss, fewer complications, and transfusion happened. The 5-year OS of ovarian cancer patients has no difference between robotic-assisted laparoscopy, laparoscopy, and laparotomy groups.

1. Background

Ovarian cancer is one of the most common gynecological malignancies worldwide, with approximately 314,000 new cases and 207,000 deaths per year [1]. Because of the absence of clinical symptoms, more than two-thirds of the diagnoses are made at advanced stages, resulting in a poor 5-year survival rate, especially in epithelial ovarian cancer (EOC) [2]. The mainstay treatment of ovarian cancer is still the traditional radical surgery combined with platinum-based chemotherapy. Satisfactory cytoreductive surgery is beneficial for the prognosis of patients with advanced ovarian cancer [3].

Traditionally, the radical surgery of ovarian cancer has been performed via laparotomy with a longitudinal median incision. A recent multicenter retrospective review of long-term outcomes after staging minimally invasive surgery for early-stage ovarian cancer suggests that minimally invasive surgery is a valuable treatment option, but the patient needs to be selected appropriately [4]. Since the da Vinci robotic surgical system was cleared for use in gynecologic surgery in the USA in 2005, its application has rapidly become more
comprehensive and widespread [5]. A robotic-assisted surgical system can provide instruments with a wrist function at the tip and a 360-degree range of motion, tremor filtration, a stable 3-dimensional vision, and an ergonomic working position [6]. It has been shown to be practical and feasible for staging and treating endometrial and cervical cancer [7, 8], whereas robotic-assisted laparoscopy surgery (RAS) in primary and recurrent ovarian cancers still remains an area of active study and debate. Recently, several meta-analyses [9–11] have directly compared the feasibility and safety between RAS, traditional laparoscopy (LS), or laparotomy (LT), but there is little literature about RAS. Therefore, we conducted a network meta-analysis, including more literature, to direct and indirect compare the efficiency and outcomes among RAS, LS, and LT in the treatment of ovarian cancer.

2. Materials and Methods

This network meta-analysis was carried out in accordance with the extension of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement for Network Meta-analyses [12].

2.1. Data Sources and Search Strategy. PubMed, Cochrane library, Embase, Web of Science, and Chinese National Knowledge Infrastructure (CNKI) were systematically searched. The search terms were ovarian neoplasm, ovarian cancer, ovarian carcinoma, ovarian tumor, peritoneoscopy, celioscopy, laparoscopy, endoscopy, laparotomy, open surgery, robot-assisted surgery, robot surgery, robot-enhanced procedures, and robotic surgical procedure. Literatures published before August 31, 2021, were searched. Taking PubMed as an example, the specific search strategy is shown in Table 1.

2.2. Inclusion and Exclusion Criteria. The literature screening was performed by two investigators separately, and the disagreements were settled by discussing with the third investigator. The literature was selected with the following criteria: [1] patients diagnosed with ovarian cancer; [2] patients underwent radical surgery, which consists of surgical staging based on hysterectomy, bilateral adnexitomy, omentectomy, pelvic and aortic lymphadenectomy (or not), and multiple peritoneal biopsies, as well as appendectomy (for mucinous histology); [3] the studies compared the outcomes of robot-assisted surgery, laparoscopy, or laparotomy; the outcomes include five-year overall survival (OS) rate, estimated blood loss (EBL)/ml, length of hospital stay (LHS)/days, operating time (OT)/min, postoperative/intraoperative complications, and pelvic/para-aortic/total lymph nodes or include at least one of them; [4] the patients with or without neoadjuvant chemotherapy were all included; and [5] published English or Chinese literature was included. Meanwhile, the literature with the following criteria were excluded: [1] data were incomplete or could not be used for statistical analysis; [2] duplicate publications; studies were reviews, abstracts, letters, and comments; [3] non-English or non-Chinese language literature; and [4] studies with less than ten patients and studies including patients treated for recurrent ovarian cancer or fertility-sparing surgery only. References of the included papers were further searched to identify other potentially relevant studies.

2.3. Data Extraction and Quality Evaluation. The data extraction and quality evaluation were carried out by two investigators, respectively, and the disagreements were settled by discussing with the third investigator. The data extracted by a standard excel form including first author's name, year of publication, study time, location, stage of ovarian cancer, the number of patients, mean age, body mass index (BMI), study design, bias score, follow-up time, and the outcomes (including OT, EBL, LHS, postoperative/intraoperative total complications, pelvic/para-aortic/total lymph nodes, transfusion, and five-years OS). Data presented as median values and ranges were converted to mean values and standard deviations (mean ± SD) using the formula proposed by Hayduk et al. [13]. For survival data, we extracted hazard ratio (HR) with a 95% confidence interval (CI) from included studies. If HR and 95% CI were not directly reported, we extracted data from Kaplan-Meier curves by Engauge Digitizeit 4.1, and we would calculate HR and 95% CI as described by Tierney [14].

We used the Newcastle–Ottawa Scale (NOS), which contained three components (selection, comparability, and outcome), to evaluate the risk of bias of included studies.

| Table 1: PubMed search strategy. |
|----------------------------------|
| **#1**                           |
| “Ovarian neoplasms”[mesh]        |
| **#2**                           |
| (((Ovarian Neoplasm[Title/Abstract]) OR (Ovarian Cancer[Title/Abstract]) OR Ovarian Carcinoma[Title/Abstract]) OR (Ovarian Tumor[Title/Abstract]) | |
| **#3**                           |
| (((Peritoneoscopy[Title/Abstract]) OR (Celioscopy[Title/Abstract]) OR (Laparoscope[Title/Abstract]) OR (Endoscope[Title/Abstract]) | |
| **#4**                           |
| (Laparotomy[Title/Abstract]) OR (Open surgery[Title/Abstract]) | |
| **#5**                           |
| (((Robot-Assisted Surgery[Title/Abstract]) OR (Robot Surgery[Title/Abstract]) OR (Robot enhanced procedures[Title/Abstract]) OR (Robotic Surgical Procedure[Title/Abstract]) | |
| **#6**                           |
| #1 OR #2                         |
| **#7**                           |
| #3 OR #4 OR #5                   |
| **#8**                           |
| #6 AND #7                        |
### Table 2: Characteristics of included studies.

| Study | Study year | Location | Stage | Group | N. | OS | Outcomes | Study design | Bias score | Follow up (m) |
|-------|------------|----------|-------|-------|----|----|----------|--------------|------------|--------------|
| 1 Chi [24] 2005 | 2000-2003 | USA | I | LS | 20 | 0 | None | Retrospective cohort | 7 | NA |
| 2 Ke-qin Hua [25] 2005 | 2002-2004 | China | I | LS | 10 | 0 | None | Retrospective cohort | 6 | NA |
| 3 Ghezzi [26] 2007 | 1997-2003 | Italy | I | LS | 15 | 0 | None | Retrospective cohort | 7 | 4-108 |
| 4 Jeong-Yeol Park [27] 2008 | 2004-2007 | Korea | I | LS | 19 | 0 | None | Prospective cohort | 7 | 1-44 |
| 5 Jeong-Yeol Park [28] 2008 | 2001-2006 | Korea | I | LS | 17 | 0 | None | Retrospective cohort | 7 | 5-61 |
| 6 Tzu-I Wu [29] 2010 | 1984-2006 | Taiwan | I | LS | 34 | 0 | None | Retrospective cohort | 8 | 2-276 |
| 7 Magrina [30] 2011 | 2002-2008 | USA | NA | LS | 27 | 0 | None | Retrospective case-control | 8 | 1-128 |
| 8 Feuer [31] 2013 | 2008-2012 | USA | I-IV | RAS | 63 | 0 | None | Retrospective cohort | 7 | 12 |
| 9 Gremeau [32] 2014 | 1989-2009 | France | I-IV | LS | 7 | 0 | None | Retrospective cohort | 8 | 8-240 |
| 10 Nezhat [15] 2014 | 2008-2012 | USA | I | LS | 10 | 0 | None | Retrospective cohort | 8 | NA |
| 11 Nezhat [15] 2014 | 2008-2012 | USA | II-IV | LS | 29 | 0 | None | Retrospective cohort | 8 | NA |
| 12 Bogani [33] 2014 | 2003-2010 | Italy | I-III | LS | 35 | 0 | None | Retrospective cohort | 8 | 37-278 |
| 13 Liu [34] 2014 | 2002-2010 | China | I-II | LS | 35 | 0 | None | Retrospective cohort | 8 | 36-84 |
| 14 Zhang [35] 2014 | 2010-2013 | China | I-III | LS | 15 | 0 | None | Retrospective cohort | 6 | NA |
| 15 Yu-Jin Koo [36] 2014 | 2006-2012 | Korea | I-II | LS | 24 | 0 | None | Retrospective cohort | 8 | >60 |
| 16 Favero [37] 2015 | 2011-2014 | Germany | IIIc-IVa | LS | 10 | 0 | None | Prospective cohort | 7 | 34 |
| Study       | Study year | Location | Stage | Group | N. | OS       | Outcomes     | Study design       | Bias score | Follow up(m) |
|-------------|------------|----------|-------|-------|----|----------|--------------|---------------------|------------|--------------|
| 17 Chen [38] 2015 | 2005-2014 | Taiwan   | IA–III | RAS   | 44 |          |              | Retrospective cohort | 7          | 29.6         |
| 18 Bellia [39] 2016 | 2006-2014 | Italy    | I-III  | RAS   | 16 |          |              | Retrospective cohort | 7          | 4-42         |
| 19 Minig [40] 2016 | 2006-2014 | Spain/Argentina | I-IV   | LS LT | 58 | √        |              | Retrospective cohort | 8          | >60          |
| 20 Ditto [41] 2016 | 2005-2015 | Italy   | I      | LS LT | 50 | √        |              | Retrospective cohort | 8          | >60          |
| 21 Lu [42] 2016 | 2002-2014 | China   | I-III  | LS LT | 42 | √        |              | Retrospective cohort | 8          | 16–152       |
| 22 Gallotta [43] 2016 | 2014-2016 | Italy   | I      | RAS   | 32 |          |              | Case-control        | 6          | NA           |
| 23 Gallotta [44] 2016 | 2000-2013 | Italy   | I      | LS LT | 60 | √        |              | Retrospective cohort | 7          | 48           |
| 24 Guidi Alletti [45] 2016 | 2013-2014 | Rome | I-IV  | LS LT | 30 |          |              | Retrospective case-control | 7          | 24           |
| 25 Xiong Wei [46] 2017 | 2007-2014 | China   | I-II   | LS LT | 71 | √        |              | Retrospective cohort | 8          | 3-103        |
| 26 Ye Mingxia [47] 2017 | 2014-2015 | China   | I      | LS LT | 10 |          |              | Retrospective cohort | 8          | 12-24        |
| 27 Huamao Liang [48] 2017 | 2007-2016 | China   | II-IV  | LS LT | 68 | √        |              | Retrospective cohort | 8          | 5-122        |
| 28 Ceccaroni [49] 2017 | 2007-2015 | Italy   | III–IV | LS LT | 45 |          |              | Prospective cohort   | 8          | >100         |
| 29 Melamed [50] 2017 | 2010-2012 | USA     | IIIIC-IV | LS LT | 450 | √        |              | Retrospective cohort | 7          | 60           |
| 30 Nam [51] 2017 | 2001-2014 | Korea   | I-II   | LS LT | 25 | √        |              | Retrospective cohort | 8          | >60          |
| 31 Brown [52] 2018 | 2006-2017 | USA     | III-IV | LS LT | 53 |          |              | Retrospective cohort | 7          | >100         |
| 32 Bergamini [53] 2018 | 1965-2017 | Italy   | I      | LS LT | 93 | √        |              | Retrospective cohort | 7          | >200         |
| Study          | Study year | Location | Stage | Group  | N. | OS | Outcomes         | Study design       | Bias score | Follow up (m) |
|---------------|------------|----------|-------|--------|----|----|------------------|--------------------|------------|---------------|
| 33 Chen Shuying [54] 2019 | 2015-2018 | China    | III-IV| RAS    | 32 | √  | ①③⑤⑥ | Retrospective cohort | 8          | 7-36          |
| 34 Jeremie [55] 2019          | 2008-2014 | Canada   | III–IV| RAS    | 57 | √  | ①⑩  | Retrospective cohort | 7          | >60           |
| 35 Facer [56] 2019            | 2010-2014 | USA      | I     | RAS    | 636| √  | ②⑨  | Retrospective cohort | 7          | >60           |
| 36 Sang [57] 2020             | 2008-2017 | Korea    | I-IV  | LS     | 57 |    | ②⑨⑩⑫ | Retrospective cohort | 7          | NA            |
| 37 Baiomy [58] 2020           | 2016-2019 | Egypt    | I-III | LS     | 30 |    | ③⑤⑥ | Retrospective cohort | 7          | 36            |
| 38 She Yujia [59] 2020        | 2013-2018 | China    | NA    | LS     | 52 |    | ①②③④⑤⑥ | Retrospective cohort | 8          | 8-56          |
| 39 Margaux Merlier [60] 2020  | 2000-2018 | French   | I-II  | LS     | 37 | √  | ②⑤⑥ | Retrospective cohort | 8          | 18-58         |

Note: ① estimated blood loss: EBL/ml; ② length of hospital stay: LHS/days; ③ operating time: OT/min; ④ postoperative complication; ⑤ intraoperative complication; ⑥ total complication; ⑦ pelvic lymph nodes; ⑧ para-aortic lymph nodes; ⑨ total lymph nodes; ⑩ transfusion; OS: overall survival (five years); NA: not available.
2.4. Statistical Analysis. Analyses were performed using Stata 14.0 (StataCorp, College Station, TX) and the R 4.0.3 software (R Foundation for Statistical Computing, Beijing, China, “meta” and “netmeta” and “gemtc” packages). For dichotomous and continuous data, we used frequentist method random-effects networks in this meta-analysis. The dichotomous data results were pooled and reported as relative risk (RRs) with 95% confidence intervals (CIs). The continuous data results were reported as standardized mean differences (SMDs) with 95% CIs. The data of OS was pooled using hazard ratio (HRs) and corresponding 95% CI. When there is a closed-loop, the consistency test is conducted between the direct comparison and the indirect comparison. When the inconsistency factor (IF) of the consistency test is close to 0, the direct and indirect evidence was considered to have consistency. Consistency between the direct and indirect evidence was also assessed by comparing the individual data point’s posterior mean deviance contributions for the consistency and inconsistency model and node splitting analysis.

3. Results

3.1. Characteristics of Included Studies. 38 studies were included in the analysis, published from 2005 to 2020, and a total of 8367 women with ovarian cancer were enrolled. The study of Nezhat et al. (2014) [15] reported perioperative outcomes for stage I and II-IV ovarian cancer, respectively.
Thus, we consider it as two studies. There were 6 three-arm studies comparing the perioperative and/or survival outcomes of ovarian cancer patients treated by robotic-assisted surgery, traditional laparoscopy, and laparotomy. There were 33 dual-arm studies, 27 of which compared laparoscopy and laparotomy, 4 compared robotic-assisted surgery and traditional laparoscopy surgery, and 2 compared robotic-assisted surgery and laparotomy. RAS-LS-LT was the only closed-loop included in the study. The characteristics of the included studies are shown in Table 2. The study selection flowchart (PRISMA) is shown in Figure 1.

3.2. Network Map. The line between two nodes represents a direct comparison. The thicker the line, the more research. The larger the node, the larger the sample size. Since only three interventions were compared in this network meta-analysis, only one closed loop was formed. The network map for each outcome variable differs only in nodes size and line thickness. We only show the network map of OT (Figure 2), which with the largest number of research included.

3.3. Operating Time (OT). 31 studies reported the operating time of different surgical approaches. Our study shows that the OT was the shortest for LT followed by RAS and finally LS; results are shown in Figure 3(a). The comparison between LT and LS was statistically significant (*p* < .05). There was no significant difference between RAS and LS groups and RAS and LT groups (*p* > .05).

3.4. Estimated Blood Loss (EBL). 28 studies reported the estimated blood loss during surgery by different surgical approaches. Our study shows that the EBL was the lowest for RAS followed by LS and finally LT; results are shown in Figure 3(b). The comparisons between RAS and LT (*p* < .001), LS and LT (*p* < .001), and RAS and LS (*p* = .018) were statistically significant.

3.5. Transfusion. 17 studies reported the incidence of transfusion with different surgical approaches. Statistical results show that the incidence of transfusion was the lowest for LS followed by RAS and finally LT; the results are shown in Figure 3(c). And the comparisons between LS and LT...
(\(p < .001\)) and RAS and LT (\(p = .004\)) were statistically significant.

3.6. Length of Hospital Stay (LHS). 26 studies reported the LHS (days) after surgery by different surgical approaches. Our study showed that the length of hospital stay was the shortest for RAS followed by LS and finally LT. The comparisons between RAS and LT and LS and LT are statistically significant (\(p < .001\)); results are shown in Figure 3(d).

3.7. Pelvic/Para-aortic/Total Lymph Nodes. 16 studies provided the number of pelvic and para-aortic lymph nodes removed by different surgical approaches. Our study showed that there is no significant difference in the number of pelvic lymph nodes.
or para-aortic lymph nodes removed among RAS, LS, and LT. Results are shown in Figures 3(e) and 4(f) ($p > 0.05$).

14 studies reported the total (pelvic and para-aortic) number of lymph nodes directly. Our study showed that there is no significant difference in the number of total lymph nodes removed among RAS, LS, and LT. Results are shown in Figure 3(g) ($p > 0.05$).

3.8. Intraoperative/Postoperative/Total Complications. 23 studies reported intraoperative complications during different surgical approaches. Statistical results showed that no significant difference in the intraoperative complications among RAS, LS, and LT. Results are shown in Figure 3(h) ($p > 0.05$).

25 studies reported postoperative complications with different surgical approaches. Statistical results showed that the incidence of postoperative complications was the lowest for LS followed by RAS and finally LT; the results are shown in Figure 3(i). The comparison between LS and LT ($p < 0.001$) was statistically significant.

### Table 3: Results of node-splitting model and loop inconsistency of perioperative outcomes.

| Outcome                      | Side       | P  | Tau | IF  | Loop inconsistency |
|------------------------------|------------|----|-----|-----|-------------------|
|                              | A B        | 0.46 | 1.02 | 0.32 | (0.00,1.51)       |
| OT                           | A C        | 0.67 | 1.02 |     |                   |
|                              | B C        | 0.25 | 1.00 |     |                   |
|                              | A B        | 0.06 | 0.43 | 0.18 | (0.00,1.03)       |
| EBL                          | A C        | 0.33 | 0.47 |     |                   |
|                              | B C        | 0.98 | 0.46 |     |                   |
|                              | A B        | 0.30 | 0.00 | 0.45 | (0.00,1.58)       |
| Transfusion                  | A C        | 0.78 | 0.17 |     |                   |
|                              | B C        | 0.24 | 0.16 |     |                   |
|                              | A B        | 0.15 | 1.13 | 1.28 | (0.00,3.03)       |
| LHS                          | A C        | 0.10 | 1.11 |     |                   |
|                              | B C        | 0.23 | 1.14 |     |                   |
|                              | A B        | 0.61 | 0.89 | 0.62 | (0.00,2.72)       |
| Pelvic lymph nodes           | A C        | 0.50 | 0.88 |     |                   |
|                              | B C        | 0.53 | 0.88 |     |                   |
|                              | A B        | 0.67 | 1.90 | 0.49 | (0.00,4.57)       |
| Para-aortic lymph nodes      | A C        | 0.79 | 1.91 |     |                   |
|                              | B C        | 0.99 | 1.92 |     |                   |
|                              | A B        | 0.17 | 0.42 | 0.50 | (0.00,1.49)       |
| Total lymph nodes            | A C        | 0.06 | 0.39 |     |                   |
|                              | B C        | 0.12 | 0.41 |     |                   |
| Intraoperative complications  | A C        | 0.14 | 0.00 |     |                   |
|                              | B C        | 0.41 | 0.00 |     |                   |
|                              | A B        | 0.08 | 0.00 | 0.70 | (0.00,2.09)       |
| Postoperative complications   | A C        | 0.31 | 0.33 |     |                   |
|                              | B C        | 0.06 | 0.00 |     |                   |
|                              | A B        | 0.41 | 0.40 | 0.12 | (0.00,1.12)       |
| Total complications           | A C        | 0.61 | 0.41 |     |                   |
|                              | B C        | 0.95 | 0.41 |     |                   |

Figure 5: Result of node-splitting analysis for OS.

29 studies reported the incidence of total (postoperative and intraoperative) complications with different surgical approaches. Statistical results showed that LS had the lowest...
Figure 6: Continued.
incidence of total complications, followed by RAS, and finally LT. And the comparisons between RAS and LT ($p = .029$) and LS and LT ($p < .001$) were statistically significant. Results are shown in Figure 3(j).

3.9. Five-Year Overall Survival (OS). 13 studies reported five-years overall survival after different surgical approaches. Brooks–Gelman–Rubin, trace, and marginal density plots showed that the network meta-analyses converged on a solution within the 50,000 iterations after the burn-in period (Figure 4). Statistical results showed no significant difference in 5-year OS between RAS, LS, and LT. Results are shown in Figure 3(k).

3.10. Risk of Heterogeneity, Inconsistency and Bias. Significant heterogeneity was demonstrated in the estimated blood loss data set. We found significant heterogeneity in the study by Neshat et al. [14], perhaps due to data conversion or inconsistent estimates of blood loss had the greatest effect. No significant heterogeneity was observed in the other outcome data sets.

The node-splitting model showed no local inconsistency in comparisons. All node splitting inconsistency $P$ values were >.05 (results of perioperative outcomes shown in Table 3 results of OS shown in Figure 5). And the loop inconsistency of perioperative outcomes also showed no inconsistency between direct and indirect comparisons (Table 3).

A funnel plot is used to assess the publication bias of the included literature, as shown in Figure 6. Except for pelvic lymph nodes, LHS, and EBL, the funnel plots of the other outcomes are basically symmetric, and most of the points are within the confidence interval. However, funnel plots of para-aortic lymph nodes and EBL showed certain publication bias. The risk of bias in the included literature is assessed by the NOS scale, and the score details are shown in Table 4.

4. Discussion

Technological advances continue to grow rapidly in the area of minimally invasive gynecologic surgery. Studies have clearly shown that minimally invasive surgery leads to faster
recovery with a shorter hospital stay, improved cosmesis, decreased blood loss, and reduced postoperative pain [16]. Robotic-assisted laparoscopic surgery is the latest innovation in the field of minimally invasive surgery and is widely used in gynecologic surgery [17].

| Study          | Year | Selection | Comparability | Assessment of outcome | Follow-up | Adequacy of follow-up | Scores |
|----------------|------|-----------|---------------|-----------------------|-----------|-----------------------|--------|
| Chi            | 2005 | *         | *             | *                     | *         | *                     | 7      |
| Ke-qin Hua     | 2005 | *         | *             | *                     |           |                       | 6      |
| Ghezzi         | 2007 | *         | *             | *                     | *         |                       | 7      |
| Jeong-Yeol Park| 2008 | *         | *             | *                     |           |                       | 7      |
| Jeong-Yeol Park| 2008 | *         | *             | *                     |           |                       | 7      |
| Tzu-I Wu       | 2010 | *         | *             | *                     | *         | *                     | 8      |
| Magrina        | 2011 | *         | *             | *                     | *         | *                     | 8      |
| Feuer          | 2013 | *         | *             | *                     |           |                       | 7      |
| Gremeau        | 2013 | *         | *             | *                     |           |                       | 8      |
| Nezhat         | 2014 | *         | *             | *                     |           |                       | 8      |
| Bogani         | 2014 | *         | *             | *                     |           |                       | 8      |
| Liu            | 2014 | *         | *             | *                     |           |                       | 8      |
| Zhang          | 2014 | *         | *             | *                     |           |                       | 6      |
| Yu-Jin Koo     | 2015 | *         | *             | *                     | *         |                       | 8      |
| Favero         | 2015 | *         | *             | *                     |           |                       | 7      |
| Chen           | 2015 | *         | *             | *                     |           |                       | 7      |
| Bellia         | 2016 | *         | *             | *                     |           |                       | 7      |
| Minig          | 2016 | *         | *             | *                     |           |                       | 8      |
| Ditto          | 2016 | *         | *             | *                     |           |                       | 7      |
| Lu             | 2016 | *         | *             | *                     | *         |                       | 8      |
| Gallotta       | 2016 | *         | *             | *                     |           |                       | 6      |
| Gallotta       | 2016 | *         | *             | *                     |           |                       | 7      |
| Gueli Alletti  | 2016 | *         | *             | *                     |           |                       | 7      |
| Xiong Wei      | 2017 | *         | *             | *                     |           |                       | 8      |
| Ye Mingxia     | 2017 | *         | *             | *                     |           |                       | 8      |
| Huamao Liang   | 2017 | *         | *             | *                     |           |                       | 8      |
| Ceccaroni      | 2017 | *         | *             | *                     |           |                       | 8      |
| Melamed        | 2017 | *         | *             | *                     |           |                       | 7      |
| Nam            | 2017 | *         | *             | *                     | *         |                       | 8      |
| Brown          | 2018 | *         | *             | *                     |           |                       | 7      |
| Bergamini      | 2018 | *         | *             | *                     |           |                       | 7      |
| Chen Shuying   | 2019 | *         | *             | *                     | *         |                       | 8      |
| Jeremie        | 2019 | *         | *             | *                     |           |                       | 7      |
| Facser         | 2019 | *         | *             | *                     |           |                       | 7      |
| Sang           | 2020 | *         | *             | *                     |           |                       | 7      |
| Baiomy         | 2020 | *         | *             | *                     |           |                       | 7      |
| She Yujia      | 2020 | *         | *             | *                     | *         |                       | 8      |
| Margaux Merlier| 2020 | *         | *             | *                     | *         |                       | 8      |

This network meta-analysis compared outcomes from 38 studies involving 8367 patients, and statistical analysis results showed no difference in the 5-year OS among the RAS, LS, and LT groups. Our analysis shows that the operating time of LT was shorter than LS ($p = 0.02$). But the
beginning and end of operative time calculation were not clearly defined in the included literature. Some studies hold that RAS needs longer device preparation time than laparoscopy and laparotomy surgery [17]. For the estimated blood loss during the surgery, RAS was the least, followed by LS, and finally LT. Compared with LT, the incidence of transfusion was lower in the RAS and LS groups, and the length of hospital stay is shorter. For complications, our analysis revealed no significant differences in intraoperative complications among the three surgical approaches. However, LT had a significantly higher incidence of postoperative complications than LS. Besides, LT had a significantly higher incidence of total complications than RAS and LS. The main complications include peripheral organ damage, bleeding, deep vein thrombosis, ileus, and infection. Our analysis revealed no statistical difference for the number of pelvic/para-aortic/total lymph nodes removed by different surgical approaches.

The safety and feasibility of traditional laparoscopy and robotic-assisted laparoscopic surgery have been proved by several studies [9, 10, 18]. Minimally invasive surgery for early-stage ovarian cancer has been widely accepted, but for advanced ovarian cancer, there remains controversy. Satisfactory cytoreductive surgery is beneficial for the prognosis of patients with advanced ovarian cancer. Due to the limitations of vision and instruments using traditional laparoscopy, it is difficult to achieve satisfactory cytoreductive in advanced ovarian cancer. An observational study of stage I epithelial ovarian cancer showed that MIS was associated with an increased risk of capsular rupture, which was associated with increased mortality [19]. Besides, laparoscopy is not suitable for huge ovarian masses, and the metastasis of puncture holes needs further exploration. Some scholars still believe that prolonged midline vertical incision is the best way to perform surgery for ovarian cancer patients. Robotic-assisted laparoscopic surgery has many advantages, including but not limited to 3-dimensional view, increased dexterity, tremor filtration, and a more favorable learning curve compared with video-assisted laparoscopy [20]. RAS improves the vision and instrument limitations of traditional laparoscopy, but the disadvantages still exist, such as long preparation time, high cost, and the instruments cannot replace the sense of the operator’s fingers. Maybe advanced science technology will solve this problem in the future.

The increasing trend of late childbearing has made fertility protection a problem needing attention. A multicenter cohort of 65 patients with stage I ovarian cancer undergoes fertility-sparing surgery by laparoscopy. They found that recurrence rates and survival rates in patients with ovarian cancer treated with MIS appeared to be comparable to those in patients via open surgery, and the conception rate was 60% for those women that wished to conceive after the procedure [21]. Two other similar studies have suggested that laparoscopic fertility-sparing surgery may be a viable option for patients with early EOC, but the number of cases is small, and more research is needed to explore [16, 22]. The advantages of MIS include smaller incisions and a lower risk of pelvic adhesion and inflammation, which are important for fertility protection [23].

The methodology of this network meta-analysis has potential limitations: [1] The included studies were case-control studies and cohort studies rather than randomized controlled studies. The surgeon may recommend the surgical approach to the patient based on the patient’s clinical data, such as tumor size, stage, and age, which may cause particular bias. [2] The comparisons between LS and LT in the included studies are much more than that between RAS and LS or LT, and there may be a potential bias. [3] Due to insufficient literature data, we did not analyze disease-free survival (DFS) and postoperative recurrence rate. Thus, the evaluation index of the patient’s postoperative prognosis is not enough, which needs more clinical research in the future.

5. Conclusions
In conclusion, our analysis showed that RAS and LS had a shorter hospital stay, decreased blood loss, fewer complications, and transfusion than LT. The survival outcomes of ovarian cancer patients have no difference between RAS, LS, and LT groups. There is a potential limitation of our network meta-analysis. More high-quality randomized controlled studies are needed, especially for advanced and recurrent ovarian cancer treated by robotic-assisted laparoscopic surgery. Thus, ovarian cancer patients will have more safe and effective surgical approach options.

Data Availability
The data used to support the findings of this study are included within the article.

Conflicts of Interest
The authors declare that they have no conflicts of interest and nothing to disclose.

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References
[1] H. Sung, J. Ferlay, R. L. Siegel et al., “Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries,” CA: a cancer journal for clinicians, vol. 71, no. 3, pp. 209–249, 2021.
[2] R. Siegel, K. Miller, and A. Jemal, “Cancer statistics, 2016,” CA: a cancer journal for clinicians, vol. 66, no. 1, pp. 7–30, 2016.
[3] J. Schorge, A. Bregar, J. Durfee, and R. Berkowitz, “Meigs to modern times: the evolution of debulking surgery in advanced ovarian cancer,” Gynecologic oncology, vol. 149, no. 3, pp. 447–454, 2018.
outcomes of early-stage ovarian cancer: a single-centre case series and systematic literature review,” *Journal of ovarian research*, vol. 7, no. 1, p. 59, 2014.

[13] A. Fagotti, F. Perelli, L. Pedone, and G. Scambia, “Current recommendations for minimally invasive surgical staging in ovarian cancer,” *Current treatment options in oncology*, vol. 17, no. 1, p. 3, 2016.

[14] D. S. Chi, N. R. Abu-Rustum, Y. Sonoda et al., “The safety and efficacy of laparoscopic surgical staging of apparent stage I ovarian and fallopian tube cancers,” *American Journal of Obstetrics and Gynecology*, vol. 192, no. 5, pp. 1614–1619, 2005.

[15] K. Q. Hua, F. M. Jin, H. Xu, Z. L. Zhu, J. F. Lin, and Y. J. Feng, “Evaluation of laparoscopic surgery in the early-stage malignant tumor of ovary with lower risk,” *Zhonghua Yi Xue Za Zhi*, vol. 85, no. 3, pp. 169–172, 2005.

[16] F. Ghezzi, A. Cromi, S. Uccella et al., “Laparoscopy versus laparotomy for the surgical management of apparent early stage ovarian cancer,” *Gynecologic oncology*, vol. 105, no. 2, pp. 409–413, 2007.

[17] J. Y. Park, D. Y. Kim, D. S. Suh et al., “Comparison of laparoscopic and laparotomy in surgical staging of early-stage ovarian and fallopian tubal cancer,” *Annals of surgical oncology*, vol. 15, no. 7, pp. 2012–2019, 2008.

[18] J. Y. Park, J. Bae, M. Lim et al., “Laparoscopic and laparotomic staging in stage I epithelial ovarian cancer: a comparison of feasibility and safety,” *International Journal of Gynecological Cancer*, vol. 18, no. 6, pp. 1202–1209, 2008.

[19] T. I. Wu, C. L. Lee, P. J. Liao et al., “Survival impact of initial surgical approach in stage I ovarian cancer,” *Chang Gung medical journal*, vol. 33, no. 5, pp. 558–567, 2010.

[20] J. F. Magrina, V. Zanagnolo, B. N. Noble, R. M. Kho, and P. Magtibay, “Robotic approach for ovarian cancer: perioperative and survival results and comparison with laparoscopy and laparotomy,” *Gynecologic oncology*, vol. 121, no. 1, pp. 100–105, 2011.

[21] G. Feuer, N. Lakhi, J. Barker, S. Salmieri, and M. Burrell, “Perioperative and clinical outcomes in the management of epithelial ovarian cancer using a robotic or abdominal approach,” *Gynecologic oncology*, vol. 131, no. 3, pp. 520–524, 2013.

[22] A. S. Gremeau, N. Bourdel, K. Jardon et al., “Surgical management of non-epithelial ovarian malignancies: advantages and limitations,” *Journal of Gynecologic Oncology*, vol. 27, no. 2, article e20, 2016.
limitations of laparoscopy,” European Journal of Obstetrics & Gynecology and Reproductive Biology, vol. 172, pp. 106–110, 2014.

[33] G. Bogani, A. Crami, M. Serati et al., “Laparoscopic and open abdominal staging for early-stage ovarian cancer: our experience, systematic review, and meta-analysis of comparative studies,” International Journal of Gynecological Cancer, vol. 24, no. 7, pp. 1241–1249, 2014.

[34] M. Liu, L. Li, Y. He et al., “Comparison of laparoscopic and laparotomy in the surgical management of early-stage ovarian cancer,” International Journal of Gynecological Cancer, vol. 24, no. 2, pp. 352–357, 2014.

[35] Z. M. Zhang, Y. Liu, J. Li, H. B. Qiu, S. Kang, and B. E. Shan, “The feasibility of comprehensive staging surgery via laparoscopic operation in patients with ovarian cancer and its clinical significance,” TUMOR, vol. 34, no. 1, pp. 55–59, 2014.

[36] Y. J. Koo, J. E. Kim, Y. H. Kim et al., “Comparison of laparoscopy and laparotomy for the management of early-stage ovarian cancer: surgical and oncological outcomes,” Journal of Gynecologic Oncology, vol. 25, no. 2, pp. 111–117, 2014.

[37] G. Favero, N. Macerox, T. Piffier et al., “Oncologic concerns regarding laparoscopic cytoreductive surgery in patients with advanced ovarian cancer submitted to neoadjuvant chemotherapy,” Oncology, vol. 89, no. 3, pp. 159–166, 2015.

[38] H. H. Chen, C. H. Chen, and W. M. Liu, “Comparison of robotics, laparoscopy and laparotomy in the management of recurrent ovarian cancer,” Journal of Minimally Invasive Gynecology, vol. 22, no. 6s, p. S239, 2015.

[39] A. Bellia, S. G. Vitale, A. S. Laganà et al., “Feasibility and surgical outcomes of conventional and robot-assisted laparoscopy for early-stage ovarian cancer: a retrospective, multicenter analysis,” Archives of gynecology and obstetrics, vol. 294, no. 3, pp. 615–622, 2016.

[40] L. Minig, J. Saadi, M. G. Patrono, M. E. Giavedoni, J. M. Cardenas-Rebollo, and M. Perrotta, “Laparoscopic surgical staging in women with early stage epithelial ovarian cancer performed by recently certified gynecologic oncologists,” European Journal of Obstetrics & Gynecology and Reproductive Biology, vol. 201, pp. 94–100, 2016.

[41] A. Ditto, G. Bogani, F. Martinelli et al., “Minimally invasive surgical staging for ovarian carcinoma: a propensity-matched comparison with traditional open surgery,” Journal of Minimally Invasive Gynecology, vol. 24, no. 1, pp. 98–102, 2017.

[42] Q. Lu, H. Qu, C. Liu, S. Wang, Z. Zhang, and Z. Zhang, “Comparison of laparoscopy and laparotomy in surgical staging of apparent early ovarian cancer,” Medicine (United States), vol. 95, no. 20, p. e3655, 2016.

[43] V. Gallotta, C. Cicero, C. Conte, G. Vizzielli, and G. Ferrandina, “Robotic versus laparoscopic staging for early ovarian cancer: a case matched control study,” Journal of Minimally Invasive Gynecology, vol. 24, no. 2, p. 293, 2017.

[44] V. Gallotta, M. Petrillo, C. Conte et al., “Laparoscopic versus laparotomic surgical staging for early-stage ovarian cancer: a case-control study,” Journal of Minimally Invasive Gynecology, vol. 23, no. 5, pp. 769–774, 2016.

[45] S. Gueli Alletti, M. Petrillo, G. Vizzielli et al., “Minimally invasive versus standard laparotomic interval debulking surgery in ovarian neoplasm: a single-institution retrospective case-control study,” Gynecologic oncology, vol. 143, no. 3, pp. 516–520, 2016.

[46] W. Xiong, L. L. Cao, L. P. Jiang, H. Xia, and Z. Q. Liang, “Clinical comparative analysis of comprehensive laparoscopic and laparotomic staging of early-stage epithelial ovarian cancer,” Zhonghua Fu Chan Ke Za Zhi, vol. 52, no. 2, pp. 103–109, 2017.

[47] M. X. Ye, L. Yu, W. S. Fan et al., “Clinical application of robotic plat form in the treatment of early ovarian cancer,” Zhonghua Yi Xue Za Zhi, vol. 97, no. 13, pp. 982–985, 2017.

[48] H. Liang, H. Guo, C. Zhang et al., “Feasibility and outcome of primary laparoscopic cytoreductive surgery for advanced epithelial ovarian cancer: a comparison to laparotomic surgery in retrospective cohorts,” Oncotarget, vol. 8, no. 68, pp. 113239–113247, 2017.

[49] M. Ceccaroni, G. Roviglione, F. Bruni et al., “Laparoscopy for primary cytoreduction with multivisceral resections in advanced ovarian cancer: prospective validation. The times they are a-changin,” Surgical endoscopy, vol. 32, no. 4, pp. 2026–2037, 2018.

[50] A. Melamed, R. Nitecki, D. M. Boruta et al., “Laparoscopy compared with laparotomy for debulking ovarian cancer after neoadjuvant chemotherapy,” Obstetrics and gynecology, vol. 129, no. 5, pp. 861–869, 2017.

[51] S. H. Nam and W. Y. Kim, “Comparison of surgical outcomes between laparoscopy and laparotomy for early-stage ovarian cancer,” European journal of gynaecological oncology, vol. 40, no. 2, pp. 262–267, 2019.

[52] J. Brown, L. Drury, E. K. Crane et al., “When less is more: minimally invasive surgery compared with laparotomy for interval debulking after neoadjuvant chemotherapy in women with advanced ovarian cancer,” Journal of Minimally Invasive Gynecology, vol. 26, no. 5, pp. 902–909, 2019.

[53] A. Bergamini, G. Ferrandina, M. Candiani et al., “Laparoscopic surgery in the treatment of stage I adult granulosa cells tumors of the ovary: results from the MITO-9 study,” European journal of surgical oncology: the journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology, vol. 44, no. 6, pp. 766–770, 2018.

[54] S. Y. Chen, “A comparison of Da Vinci robotic-assisted surgical system vs traditional laparoscopy in advanced ovarian cancer”.

[55] J. Abitbol, W. Gotlieb, Z. Zeng, A. Ramanakumar, and S. Lau, “Incorporating robotic surgery into the management of ovarian cancer after neoadjuvant chemotherapy,” International Journal of Gynecological Cancer, vol. 29, no. 9, pp. 1341–1347, 2019.

[56] B. Facer, F. Wang, C. G. Grijalva, R. D. Alvarez, and X. O. Shi, “Survival outcomes for robotic-assisted laparoscopy versus traditional laparoscopy in clinical stage I epithelial ovarian cancer,” American Journal of Obstetrics and Gynecology, vol. 222, no. 5, 2020.

[57] J. H. Sang and S. H. Chung, “Is it enough in ovarian cancer staging surgery to laparoscopic surgery? Comparison of surgical methods,” European journal of gynaecological oncology, vol. 41, no. 4, pp. 541–544, 2020.

[58] T. A. Baiomy, O. H. Khalil, W. M. Abdallah et al., “Ovarian cancer surgical staging, laparoscopy versus laparotomy: a comparative study,” Journal of Gynecologic Surgery, vol. 36, no. 4, pp. 179–183, 2020.

[59] Y. J. She, M. X. Ye, and Y. G. Meng, “Comparison of effects of robotic surgery, laparoscopy surgery and laparotomy in treatment of ovarian cancer,” Acad J Chin PLA Med Sch, vol. 4, no. 41, 2020.

[60] M. Merlier, Y. Kerbage, A. Pierache et al., “Impact on prognosis of the surgical route, laparoscopy or laparotomy, for the surgical staging of early stage ovarian cancer-a study from the FRANCOGYN group,” Journal of Clinical Medicine, vol. 9, no. 11, p. 3528, 2020.