# Laparoscopic and robotic hysterectomy in endometrial cancer patients with obesity: a systematic review and meta-analysis of conversions and complications

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**OBJECTIVE DATA:** Robotic assistance may facilitate completion of minimally invasive hysterectomy, which is the standard of care for the treatment of early-stage endometrial cancer, in patients for whom conventional laparoscopy is challenging. The aim of this systematic review was to assess conversion to laparotomy and perioperative complications after laparoscopic and robotic hysterectomy in patients with endometrial cancer and obesity (body mass index, $\geq$30 kg/m$^2$).

**STUDY:** We systematically searched MEDLINE, EMBASE, and Evidence-Based Medicine Reviews (January 1, 2000, to July 18, 2018) for studies of patients with endometrial cancer and obesity (body mass index, $\geq$30 kg/m$^2$) who underwent primary hysterectomy.

**STUDY APPRAISAL AND SYNTHESIS METHODS:** We determined the pooled proportions of conversion, organ/vessel injury, venous thromboembolism, and blood transfusion. We assessed risk of bias with the Institute of Health Economics Quality Appraisal Checklist for single-arm studies, and Newcastle-Ottawa Quality Scale for double-arm studies.

**RESULTS:** We identified 51 observational studies that reported on 10,800 patients with endometrial cancer and obesity (study-level body mass index, 31.0—56.3 kg/m$^2$). The pooled proportions of conversion from laparoscopic and robotic hysterectomy were 6.5% (95% confidence interval, 4.3—9.9) and 5.5% (95% confidence interval, 3.3—9.1), respectively, among patients with a body mass index of $\geq$30 kg/m$^2$, and 7.0% (95% confidence interval, 3.2—14.5) and 3.8% (95% confidence interval, 1.4—9.9) among patients with body mass index of $\geq$40 kg/m$^2$. Inadequate exposure because of adhesions/visceral adiposity was the most common reason for conversion for both laparoscopic (32%) and robotic hysterectomy (61%); however, intolerance of the Trendelenburg position caused 31% of laparoscopic conversions and 6% of robotic hysterectomy conversions. The pooled proportions of organ/vessel injury (laparoscopic, 3.5% [95% confidence interval, 2.2—5.5]; robotic hysterectomy, 1.2% [95% confidence interval, 0.4—3.4]), venous thromboembolism (laparoscopic, 0.5% [95% confidence interval, 0.2—1.2]; robotic hysterectomy, 0.5% [95% confidence interval, 0.1—2.0]), and blood transfusion (laparoscopic, 2.8% [95% confidence interval, 1.5—5.1]; robotic hysterectomy, 2.1% [95% confidence interval, 1.6—3.8]) were low and not appreciably different between arms.

**CONCLUSION:** Robotic and laparoscopic hysterectomy have similar rates perioperative complications in patients with endometrial cancer and obesity, but robotic hysterectomy may reduce conversions because of positional intolerance in patients with morbid obesity. Existing literature is limited by selection and confounding bias, and randomized trials are needed to inform practice standards in this population.

**Key words:** complication, conversion to laparotomy, endometrial cancer, hysterectomy, laparoscopy, obesity

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## AJOG at a Glance

### Why was this study conducted?

The purpose of this study was to evaluate rates of conversion to laparotomy and other perioperative complications with laparoscopic and robotic hysterectomy, specifically in patients with endometrial cancer and obesity (body mass index, >30 kg/m$^2$).

### Key findings

Conversion rates were similar for laparoscopic and robotic hysterectomy in patients with body mass index of ≥30 kg/m$^2$ but were higher for laparoscopic vs robotic hysterectomy in patients with body mass index of ≥ 40 kg/m$^2$. Positional intolerance was responsible for 31% of laparoscopic conversions and 6% of robotic conversions. Rates of organ/vessel injury, blood transfusion, and venous thromboembolism were similar with laparoscopic and robotic hysterectomy.

### What does this add to what is known?

This review is the first to demonstrate that robotic hysterectomy may offer clinical benefit over laparoscopic hysterectomy specifically in the context of obesity, which now affects >50% of patients with a diagnosis of endometrial cancer. We derived estimates of complication rates in this high-risk population that are useful for preoperative counselling.

Obesity is a major risk factor for endometrial cancer, and nearly 65% of patients with endometrial cancer who undergo primary hysterectomy have concurrent obesity (body mass index [BMI], 30-40 kg/m$^2$; 35−40%) or morbid obesity (BMI, ≥40 kg/m$^2$; 25−30%).[1,2] Although data from randomized controlled trials has shown that laparoscopic hysterectomy results in reduced operative morbidity, shorter hospital stays, and noninferior oncologic outcomes when compared with open hysterectomy,[3−10] this approach may be underused or unsuccessful in patients with obesity because of technical challenges, limited exposure, and cardiopulmonary compromise while in the Trendelenburg position.[11] Total laparoscopic hysterectomy is performed for only 50% of this patient population,[12] and studies such as the Gynecologic Oncology Group LAP2 trial have illustrated that the odds of conversion to laparotomy during laparoscopic staging increase significantly with each unit increase in BMI (odds ratio, 1.11; 95% confidence interval [CI], 1.09−1.13).[8]

Given the challenges that are associated with conventional laparoscopy in patients with obesity, robotic surgery has been used as an alternative.[13] Wristed instruments may optimize operative technique and exposure, while fixed mechanical arms support the weight of the abdominal wall and facilitate ventilation by allowing for reduced intraperitoneal/intrathoracic pressures.[13−15] Although such advantages may assist in completion of minimally invasive hysterectomy, robotic surgery is costly, and previous systematic reviews have shown no differences in conversions or other complications between laparoscopic and robotic surgery.[16−18] The mean/median BMI of the studies included in these reviews ranged from 24−32 kg/m$^2$, but the mechanical advantages of robotic surgery may only translate into improved outcomes among patients for whom standard laparoscopy is especially challenging, such as patients with obesity.

Evidence of clinical benefit for robotic surgery in patients with obesity would justify the additional resources required for this approach and may thus improve the adoption of minimally invasive surgery for this high-risk population.[12] This issue is pressing because rates of obesity and endometrial cancer are rising rapidly in parallel.[19] Our systematic review and meta-analysis therefore aims to evaluate rates of conversion to laparotomy and perioperative complications with laparoscopic (LH) or robotic hysterectomy (RH), specifically in patients with endometrial cancer and obesity (BMI, ≥30 kg/m$^2$).

## Methods

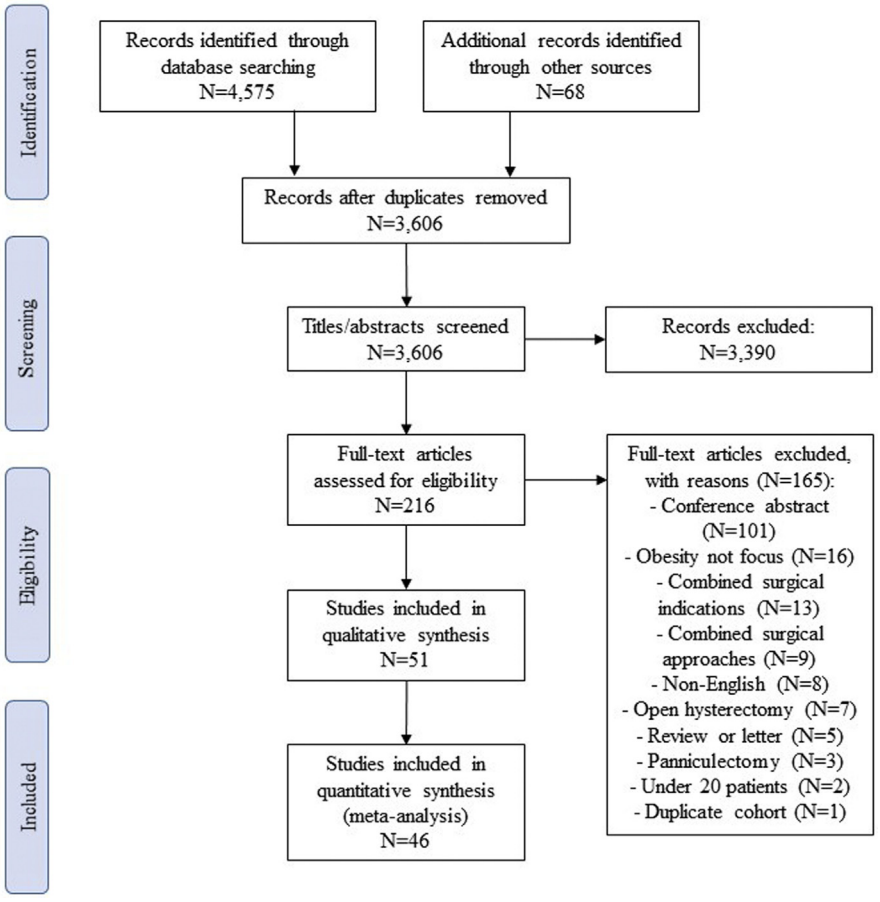
### Eligibility criteria

The protocol for this study was prospectively registered with PROSPERO (CRD42016049045). We included studies in which (1) the patient population of focus was at minimum 20 women with endometrial cancer and obesity (BMI, ≥30 kg/m$^2$), (2) the intervention of interest was LH (total laparoscopic, laparoscopic-assisted vaginal hysterectomy) or RH, either with or without lymphadenectomy, (3) perioperative outcomes were reported separately for each approach (LH or RH), and (4) the design was a randomized controlled trial or an observational study (single-arm or double-arm). We opted to include patients with endometrial cancer only, because in contrast to patients with benign or premalignant surgical indications, they often require simultaneous lymphadenectomy and may have unique operative findings (ie, advanced/metastatic disease) that affect the rate of conversion to laparotomy.

We excluded studies that reported on cohorts with obesity but failed to meet the aforementioned criteria because they (1) failed to distinguish between patients with endometrial cancer and other indications for surgery, (2) reported on open hysterectomy or simultaneous panniculectomy only, (3) failed to report outcomes separately for LH or RH, or (4) were case reports, case series, or reviews/commentaries without original data. Observational studies that sampled patients based on exposure were deemed cohort studies, whereas those that sampled patients based in part or entirely on outcomes were deemed case series, irrespective of sample size.[20]

We also excluded non-English studies or conference abstracts, even if they otherwise met inclusion criteria. Previous work has shown no evidence of bias with the use of language restrictions in systematic reviews on medical topics,[21] while conference abstracts often report preliminary results that vary

**FIGURE 1**
**Preferred Reporting Items for Systematic Reviews and Metaanalyses flow diagram of systematic screening process**

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substantially from what ultimately is published and contain insufficient detail to perform an assessment of methodologic quality and risk of bias.[22,23]

### Information sources and literature search

A senior information specialist at St. Michael's Hospital (Toronto, Canada) searched MEDLINE, EMBASE, and Evidence-Based Medicine Reviews from January 1, 2000, to July 18, 2018, after receiving detailed input from the research team (Appendix 1). We limited our search to the year 2000 onward to capture the uptake of minimally invasive surgery in gynecology.[24] Database results were supplemented by hand-searching the reference lists of recent systematic reviews[25–29] and clinical practice guidelines[13,14] on similar topics, reviewing the first 10 pages of Google Scholar, and citation tracking of the included studies.

### Study selection and data collection process

Two reviewers independently reviewed all citations for eligibility in 2 stages (titles/abstracts and full-text) with the use of standardized electronic screening forms on DistillerSR software (Evidence Partners, Ottawa, Ontario, Canada). All conflicts were resolved by discussion. Two reviewers independently extracted data from the included studies using a piloted data form. We collected study characteristics (author, year of publication, country, study design, study period, sample size, inclusion and exclusion criteria, follow-up time), patient characteristics (age, BMI, comorbidities, clinical stage, histologic condition, grade, pathologic stage), and outcomes. Authors were contacted if data were not reported separately for patients with endometrial cancer or for those undergoing LH or RH.

Our primary outcome was the proportion of patients with obesity who required conversion from a minimally invasive approach (LH or RH) to an open approach. Reasons for conversion were categorized as (1) organ/vessel injury, (2) uterine size, (3) advanced/metastatic disease, (4) inadequate exposure because of adhesions or visceral adiposity, (5) anesthetic indications related to an intolerance of the Trendelenburg position, and (6) equipment malfunction. Secondary outcomes were the proportion of patients who experienced an organ (bladder, bowel, or ureter) or major vessel injury, the proportion of patients who required at least 1 perioperative blood transfusion, and the proportion of patients who experienced postoperative venous thromboembolism (VTE). We selected outcomes a priori because they are common complications that are highlighted by gynecologic surgeons in consent discussions[30] and because we expected their definitions to be consistent across studies and thus appropriate for meta-analysis. Additional outcomes such as estimated blood loss, operative time, length of hospital stay, and proportion of patients with wound complications were collected for descriptive purposes only (Appendix 2).

### Risk of bias assessment

We assessed risk of bias in single-arm studies using the 20-item Institute of Health Economics Quality Appraisal Checklist.[31] Although initially designed for case series, this checklist has been previously adapted successfully to cohort studies.[32–34] In keeping with prior work, we gave 1 point for "yes" answers, 0.5 points for "partial/unclear" answers, and 0 points for "no" answers and classified studies as being at low (80–100%), moderate (60–79%), or high risk (0–59%) of bias based on their overall

percentage score.[32–34] We assessed risk of bias in double-arm studies using the 8-item Newcastle-Ottawa Quality Assessment Scale.[35] Studies were classified as being at low (7–9), moderate (4–6), or high (0–3) risk of bias based on their overall point score.[32,36] Both scales evaluate broad sources of bias that include selection and attrition bias, exposure/outcome ascertainment bias, and confounding bias, rather than topic-specific issues (eg, whether reasons for conversion were documented). Two reviewers applied the Institute of Health Economics and Newcastle-Ottawa Quality Assessment Scale independently, and all conflicts were resolved by discussion. Publication bias for our primary outcome (conversion to laparotomy) was evaluated with the use of funnel plots with the proportion of conversions on the x-axis and standard error on the y-axis.

### Synthesis of results

We pooled outcomes separately for patients who underwent LH or RH. This approach allowed us to make use of data from both the single-arm and double-arm studies that were identified but did not permit direct statistical comparisons between LH and RH. Proportions (conversion to laparotomy, blood transfusion, organ/vessel injury, VTE) were pooled with a generalized linear/mixed-effects model and exact likelihood approach based on a binomial distribution. For meta-analyses of studies with rare/zero events such as ours, this approach provides unbiased estimates relative to standard approximate normal methods and avoids the need for an arbitrary continuity correction in the case of zero events.[37,38] We generated forest plots to display outcomes for each study with their corresponding 95% confidence interval (CI) and the overall random-effects pooled estimate with its 95% CI.

For the primary outcome (conversion to laparotomy), we performed a subgroup analysis in patients with a BMI of $\geq$40 kg/m$^2$ and a sensitivity analysis that removed studies that excluded patients with risk factors for conversion (ie, chronic obstructive pulmonary disease, congestive heart failure, myocardial infarction) because we expected such characteristics to introduce heterogeneity. We evaluated statistical heterogeneity with the use of the $I^2$ statistic and defined heterogeneity as notable when $I^2$>50%. Metaanalyses were performed using the *metafor* package in R.

### Changes to protocol

This review was carried out according to our prospectively registered protocol (CRD42016049045). Although the protocol does not specifically mention the exclusion of studies that evaluated hysterectomy with panniculectomy only, this decision was made a priori by the study team because of anticipated differences in outcomes with such studies.

## Results

### Study selection

We identified 4575 records in MEDLINE, EMBASE, and Evidence-Based Medicine Reviews (Figure 1). We identified an additional 68 records through hand-searching and citation tracking. After deduplication, there were 3606 articles remaining for evaluation; 3390 articles were excluded during title/abstract screening, which left 216 articles for full-text screening.

Of the 216 full-text articles that initially were reviewed, there were 24 that included cohorts with obesity but failed to distinguish between patients with endometrial cancer and other indications for surgery (n=15) or failed to report outcomes separately for patients who underwent LH or RH (n=9). We contacted the authors of these articles to request aggregate data; two authors responded and their articles are included in this review, but all others were excluded (n=22). Additional reasons for full-text exclusion (n=143) are outlined in Figure 1 and Appendix 3.

There were ultimately 51 articles eligible for qualitative synthesis and 46 articles eligible for quantitative synthesis. No identified randomized controlled trials met our inclusion/exclusion criteria; this is therefore a systematic review of observational studies only.

### Summary of included studies

The characteristics of included studies are presented in Table 1.[1,2,39–87] There were 22 single-arm (LH, 16; RH, 6) [39–43,49,53,54,57,58,60,64,65,67–69,73–76,79,83] and 29 double-arm studies (OH/LH, 18; OH/RH, 6; LH/RH, 1; OH/LH/RH, 4)[1,2,44–48,50–52,55,56,59,61–63,66,70–72,77,78,80–82,84–87] that included a median of 86 patients (interquartile range, 54–195) with BMI of $\geq$30 kg/m$^2$. Mean or median BMI was provided in 29 studies (57%) and ranged from 31.0–55.4 kg/m$^2$ for LH arms (21 studies) and 37.5–56.3 kg/m$^2$ for RH arms (10 studies). The criteria for concurrent lymphadenectomy were highly variable across studies; thus, the proportion of patients who received lymphadenectomy ranged from 14–100% for LH arms and 44–100% for RH arms. Studies did not describe whether surgeons were allowed to, or chose to, forego lymphadenectomy to avoid conversion and maintain an LH or RH approach.

The 51 included studies reported on a total of 10,800 patients with BMI of $\geq$30 kg/m$^2$. Baseline characteristics for patients in each study are presented in Appendix 2. Although clinical stage was noted explicitly in only 24 studies (47%), final pathologic stage was reported in 39 studies (76%) and specifically for patients with BMI of $\geq$30 kg/m$^2$ in 28 studies (55%). In these studies, 89% of patients (1735/1955) had stage I–II disease on final pathology reports.

Characteristics that may have influenced the decision to choose an open vs minimally invasive approach or robotic vs laparoscopic approach were reported rarely. Important comorbidities such as diabetes mellitus and cardiopulmonary disease were reported among patients with obesity in 5 studies (10%); a history of previous abdominal surgery was reported among patients with obesity in 15 studies (29%).

### Conversion to laparotomy

The pooled proportions of patients with BMI of $\geq$30 kg/m$^2$ who required laparotomic conversion were 6.5% (95% CI, 4.3–9.9) for LH and 5.5% (95% CI, 3.3–9.1) for RH (Figure 2). This corresponded to 173 events among 1826 patients with LH (29 studies)[39,40,42,45,46,48,49,51,55–60,62,64,66,68,70,72–74,76,78,79,81,82,86,87] and 91 events

**TABLE 1**
**Characteristics of included studies**

| First author | Year | Country | Study design | Body mass index criteria, kg/m$^2$ | Type of hysterectomy | Sample size, n | Body mass index, kg/m$^2$[a] | Clinical stage | Selection criteria | Follow up[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Backes[41] | 2015 | USA | Retrospective single center | ≥30 | RH | 380 | NR | NR | No detail on how selected for RH<br>Exclusion: conversions | NR |
| Baek[42] | 2014 | Korea | Retrospective single center | ≥28 | LH | 55 | 31.0 (3.0) | Early stage | No detail on how selected for LH<br>Exclusion: missing data, inadequate follow up | 74 (6–152) Mo |
| Bennich[43] | 2016 | Denmark | Retrospective single center | ≥30 | LH | 97 | 30–54 | Stage I | All patients received LH in study period<br>Exclusion: advanced/ metastatic disease | NR |
| Bernardini[44] | 2012 | Canada | Prospective single center | ≥35 | OH | 41 | 42.3 (36–66) | NR | Diagnostic laparoscopy for uterine size at start of case to determine OH or RH<br>Exclusion: NR | NR |
| | | | | | RH | 45 | 40.3 (35–75) | | | |
| Bige[45] | 2015 | Turkey | Prospective single center | ≥35 | OH | 70 | 45.9 (7.2) | Stage I | All patients offered LH; those who refused assigned to OH<br>Exclusion: stage II–IV, previous abdominopelvic surgery/ radiation, cardiopulmonary disease that precluded the Trendelenburg position, large uterus, severe orthopedic disease | 31 Mo |
| | | | | | LH | 70 | 44.5 (7.0) | | | 35 Mo |
| Bijen[46] | 2011 | Nether-lands | Prospective single center | >35 | OH | 24 | 30–55 | Stage I | Secondary analysis of randomized controlled trial database<br>Exclusion: stage II–IV, non-endometrioid histology, large uterus, cardiopulmonary disease that precluded the Trendelenburg position | NR |
| | | | | | LH | 31 | 30–48 | | | |
| Borgfeldt[47] | 2016 | Sweden | Retrospective national registry | ≥35 | OH | 358 | NR | NR | No detail on how selected for LH/RH<br>Exclusion: NR | NR |
| | | | | | LH | 32 | NR | | | |
| | | | | | RH | 63 | NR | | | |

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(continued)

**TABLE 1**
**Characteristics of included studies** *(continued)*

| First author | Year | Country | Study design | Body mass index criteria, kg/m$^2$ | Type of hysterectomy | Sample size, n | Body mass index, kg/m$^2$[a] | Clinical stage | Selection criteria | Follow up[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Bouwman[48] | 2015 | UK | Retrospective single center | ≥30 | OH | 146 | NR | NR | No detail on how selected for LH<br>Exclusion: missing data, sarcoma | NR |
| | | | | | LH | 114 | NR | | | |
| Camanni[49] | 2010 | Italy | Retrospective single center | ≥30 | LH | 10 | NR | Stage I | No detail on how selected for LH<br>Exclusion: NR | NR |
| Chan[50] | 2015 | USA | Retrospective Nationwide Inpatient Sample—Healthcare Cost and Utilization Project | ≥40 | OH | 567 | NR | NR | No detail on how selected for LH or RH<br>Exclusion: NR | NR |
| | | | | | LH | 98 | NR | | | |
| | | | | | RH | 422 | NR | | | |
| Cheng[51] | 2016 | China | Retrospective single center | >40 | OH | 60 | 45.8 (40—75) | Stage I-II | No detail on how selected for LH<br>Exclusion: non-endometrioid histologic condition | NR |
| | | | | | LH | 60 | 46.3 (40—66) | | | |
| Cohn[52] | 2009 | USA | Retrospective multicenter | ≥30 | OH | 191 | 39.9 (6.9) | Stage I-II | No detail on how selected for LH<br>Exclusion: NR | NR |
| | | | | | RH | 109 | 39.6 (7.0) | | | |
| Corrado[53,92] | 2015 | Italy | Prospective multicenter | ≥40 | RH | 70 | 40—57 | NR | Not eligible for RH if large uterus or contraindication to the Trendelenburg position<br>Exclusion: as per selection eligibility criteria | 20 (5—56) Mo |
| Cunningham[54] | 2015 | USA | Retrospective single center | ≥30 | RH | 211 | 30—71 | NR | Selected for RH at surgeon discretion; no patients ineligible based on body mass index or the Trendelenburg position stress test<br>Exclusion: NR | 30 D |
| Eisenhauer[55] | 2007 | USA | Retrospective single center | ≥35 | OH | 154 | 41 (35—84) | NR | Selected for LH at surgeon discretion; considered body habitus/medical history<br>Exclusion: Gynecologic Oncology Group LAP2 trial enrollment | NR |
| | | | | | LH | 25 | 39 (35—49) | | | |

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*(continued)*

**TABLE 1**
**Characteristics of included studies** *(continued)*

| First author | Year | Country | Study design | Body mass index criteria, kg/m$^2$ | Type of hysterectomy | Sample size, n | Body mass index, kg/m$^2$[a] | Clinical stage | Selection criteria | Follow up[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Eltabbakh[56] | 2000 | USA | Prospective single center | 28-60 | OH | 40 | 36.9 (8.5) | Stage I | Not eligible for LH if body mass index >60 kg/m$^2$, large uterus, cervical involvement, cardiopulmonary disease that precluded the Trendelenburg position, or hip disease that precluded lithotomy<br>Exclusion: as per selection eligibility criteria | NR |
| | | | | | LH | 40 | 35.8 (5.8) | | | |
| Fanning[57] | 2010 | USA | Retrospective single center | ≥40 | LH | 85 | 40–77 | NR | All patients selected for LH regardless of age, body mass index, uterine size, and previous surgery<br>Exclusion: no exclusions | NR |
| Farthing[58] | 2012 | UK | Retrospective single center | ≥30 | LH | 114 | NR | Stage I-II | No detail on how selected for LH<br>Exclusion: endometrial hyperplasia | NR |
| Gehrig[59] | 2008 | USA | Retrospective single center | ≥30 | LH | 32 | 35 (30–55) | NR | No detail on how selected for LH/RH<br>Exclusion: NR | NR |
| | | | | | RH | 49 | 37.5 (30–53) | | | |
| Ghezzi[60] | 2006 | Italy | Retrospective single center | ≥30 | LH | 22 | 30–46 | NR | Not eligible for LH if cardiopulmonary disease precluded the Trendelenburg position or advanced/metastatic disease<br>Exclusion: as per selection eligibility criteria | 13 (1–38) Mo |
| Giugale[61] | 2012 | USA | Retrospective multicenter | ≥30 | OH | 379 | 44.0 | NR | No detail on how selected for LH/RH<br>Exclusion: missing data | 24 months |
| | | | | | LH/RH | 280 | 41.7 | | | |
| Helm[62] | 2011 | USA | Retrospective single center | ≥36 | OH | 56 | NR | Early stage | Selected for RH at surgeon discretion<br>Exclusion: NR | 17 Mo |
| | | | | | LH | 29 | NR | | | |
| Hinshaw[63] | 2016 | USA | Retrospective single center | ≥35 | OH | 80 | 44.2 | NR | Selected for RH at surgeon discretion<br>Exclusion: LH or VH | 60 Mo |
| | | | | | RH | 56 | 42.6 | | | 37 Mo |

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*(continued)*

**TABLE 1**
**Characteristics of included studies** *(continued)*

| First author | Year | Country | Study design | Body mass index criteria, kg/m$^2$ | Type of hysterectomy | Sample size, n | Body mass index, kg/m$^2$[a] | Clinical stage | Selection criteria | Follow up[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Holub[64] | 2000 | Czech Republic | Retrospective single center | ≥30 | LH | 33 | 30–40 | Stage I | No detail on how selected for LH<br>Exclusion: NR | NR |
| Lau[65] | 2011 | Canada | Retrospective single center | ≥30 | RH | 56 | 30–59 | NR | All patients selected for RH regardless of body habitus, medical/surgical history<br>Exclusion: NR | NR |
| Leitao[66] | 2016 | USA | Retrospective single center | ≥40 | OH | 299 | NR | NR | No detail on how selected for LH/RH<br>Exclusion: VH | NR |
| | | | | | LH | 43 | NR | | | |
| | | | | | RH | 90 | NR | | | |
| Litta[67] | 2013 | Italy | Retrospective single center | ≥30 | LH | 34 | NR | Stage I-II | Not eligible for LH if >75 years old, cardiopulmonary disease that precluded the Trendelenburg position, renal/hepatic/hematologic dysfunction, previous abdominopelvic radiation<br>Exclusion: as per selection eligibility criteria | 30 D |
| Mahdi[1] | 2015 | USA | Retrospective American College of Surgeons National Surgical Quality Improvement Program | ≥30 | OH | 1304 | NR | NR | No detail on how selected for LH<br>Exclusion: perioperative sepsis | 30 D |
| | | | | | LH | 1133 | NR | | | |
| Matsuo[68] | 2016 | USA | Retrospective single center | ≥30 | LH | 163 | NR | NR | No detail on how selected for LH<br>Exclusion: NR | NR |
| Menderes[69] | 2014 | USA | Retrospective single center | ≥30 | RH | 239 | NR | NR | All patients selected for RH regardless of body habitus, previous surgical history, or pelvic metastatic disease<br>Exclusion: NR | 29 (interquartile range, 16–43) Mo |
| Mendivil[70] | 2015 | USA | Retrospective single center | >40 | OH | 24 | 53.7 (41–65) | NR | Selected for LH/RH at surgeon discretion<br>Exclusion: no pelvic lymphadenectomy performed | 57 (22–156) Mo |
| | | | | | LH | 16 | 47.9 (40–62) | | | |
| | | | | | RH | 13 | 51.2 (41–64) | | | |

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*(continued)*

**TABLE 1**
**Characteristics of included studies** *(continued)*

| First author | Year | Country | Study design | Body mass index criteria, kg/m$^2$ | Type of hysterectomy | Sample size, n | Body mass index, kg/m$^2$[a] | Clinical stage | Selection criteria | Follow up[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Nevadunsky[71] | 2010 | USA | Retrospective single center | ≥30 | OH | 43 | 37 (30–61) | NR | No detail on how selected for RH<br>Exclusion: conversions | NR |
| | | | | | RH | 66 | 38.5 (30–63) | | | |
| Obermair[73] | 2005 | Australia | Retrospective multicenter | ≥100kg | OH | 31 | NR | NR | Not eligible for LH if large uterus or extrauterine disease on computed tomography scan<br>Exclusion: NR | 24 (17–31) Mo |
| | | | | | LH | 47 | NR | | | |
| Obermair[72] | 2016 | Australia | Prospective multicenter | >30 | LH | 26 | 40.1 (29–55) | Early stage | No detail on how selected for LH<br>Exclusion: stage II–IV, non-endometrioid histologic condition, enlarged lymph nodes, CA-125 >30 | 30 D |
| O'Gorman[74] | 2008 | UK | Retrospective single center | ≥30 | LH | 34 | 30–60 | Early stage | No detail on how selected for LH<br>Exclusion: NR | NR |
| O'Hanlan[75] | 2006 | USA | Retrospective single center | ≥30 | LH | 38 | NR | Early stage | Not eligible for LH if severe adhesions or advanced/ metastatic disease<br>Exclusion: as per selection eligibility criteria | NR |
| Palomba[76] | 2007 | Italy | Retrospective single center | >30 | LH | 151 | 34.5 (1.6) | Early stage | No detail on how selected for LH<br>Exclusion: previous abdominopelvic radiation, major medical comorbidities, severe hip disease, second malignancy | NR |
| Pellegrino[77] | 2009 | Italy | Retrospective single center | >30 | OH | 37 | NR | Stage I | No detail on how selected for LH<br>Exclusion: NR | 16 Mo |
| | | | | | LH | 37 | 38 (30–47) | | | |
| Peng[40] | 2018 | Canada | Retrospective single center | ≥30 | LH | 101 | 38 (7.6) | NR | Selected for LH at surgeon discretion<br>Exclusion: Unknown body mass index | NR |
| Perrone[78] | 2012 | Italy | Retrospective single center | ≥30 | OH | NR | NR | Stage I-IIA | Not eligible for LH if large uterus or cardiopulmonary disease that precluded the Trendelenburg position<br>Exclusion: as per selection eligibility criteria | NR |
| | | | | | LH | 43 | 35.2 (4.3) | | | |

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*(continued)*

**TABLE 1**
**Characteristics of included studies** *(continued)*

| First author | Year | Country | Study design | Body mass index criteria, kg/m$^2$ | Type of hysterectomy | Sample size, n | Body mass index, kg/m$^2$[a] | Clinical stage | Selection criteria | Follow up[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Rabischong[79] | 2011 | France | Retrospective multicenter | ≥30 | LH | 52 | 34.2 (30–56) | Stage I | Not eligible for LH if anesthetic contraindication to pneumoperitoneum, bulky uterus, enlarged lymph nodes<br>Exclusion: conversions | 69 (14–194) Mo |
| Ramzan[80] | 2015 | USA | Retrospective multicenter | ≥50 | OH | 20 | 57.5 (6.1) | NR | No detail on how selected for LH<br>Exclusion: endometrial hyperplasia, sarcoma, advanced/metastatic disease | NR |
| | | | | | LH | 20 | 55.4 (5.8) | | | |
| Rizzuto[39] | 2014 | UK | Retrospective single center | ≥30 | LH | 37 | 36.8 (5.3) | Early stage | Not eligible for LH if cardiopulmonary disease that precluded the Trendelenburg position<br>Exclusion: as per selection eligibility criteria | NR |
| Santi[81] | 2009 | Switzer-land | Retrospective single center | ≥30 | OH | NR | NR | Early stage | No detail on how selected for LH<br>Exclusion: previous malignancy | NR |
| | | | | | LH | 31 | NR | | | |
| Scribner[82] | 2002 | USA | Retrospective single center | ≥28 | OH | 45 | 39.3 (28–68) | Stage I | No patients ineligible based on age, weight, or previous surgical history<br>Exclusion: NR | NR |
| | | | | | LH | 55 | 40 (28–62) | | | |
| Stephan[83] | 2015 | USA | Retrospective single center | ≥50 | RH | 56 | 56.3 | Early stage | Selected for RH based on availability of qualified surgeon and robotic platform<br>Exclusion: NR | 31 Mo |
| Subramaniam[84] | 2011 | USA | Retrospective single center | ≥30 | OH | 104 | 41.9 (9.3) | NR | Selected for RH at surgeon discretion<br>Exclusion: NR | NR |
| | | | | | RH | 73 | 39.8 (9.3) | | | |
| Suidan[2] | 2017 | USA | Retrospective health claims database | ≥30 | OH | 285 | NR | NR | No detail on how selected for LH/RH<br>Exclusion: lack of continuous insurance coverage for 3 mo postoperatively, incomplete data | NR |
| | | | | | LH/RH/VH | 442 | NR | | | |
| Tang[85] | 2012 | USA | Retrospective single center | ≥30 | OH | 110 | 40.3 (8.6) | NR | Not eligible for RH if large uterus weeks<br>Exclusion: NR | NR |
| | | | | | RH | 129 | 39.8 (7.9) | | | |

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*(continued)*

**TABLE 1**
**Characteristics of included studies** *(continued)*

| First author | Year | Country | Study design | Body mass index criteria, kg/m$^2$ | Type of hysterectomy | Sample size, n | Body mass index, kg/m$^2$[a] | Clinical stage | Selection criteria | Follow up[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Tinelli[86] | 2014 | Italy | Retrospective multicenter | >35 | OH | 30 | 39 (8.1) | Stage I | Not eligible for LH if large uterus or cardiopulmonary disease that precluded the Trendelenburg position<br>Exclusion: advanced/metastatic disease, previous radiation/chemotherapy, systemic infection, incomplete follow up | 48 (3–97) Mo |
| | | | | | LH | 45 | 38 (7.3) | | | |
| Uccella[93] | 2015 | Italy | Retrospective multicenter | ≥30 | OH | 161 | 30–61 | NR | No detail on how selected for LH<br>Exclusion: stage IV disease, incomplete data, follow up <6 mo | NR |
| | | | | | LH | 239 | 30–62 | | | |

*LH*, laparoscopic hysterectomy; *NR*, not reported; *OH*, open hysterectomy; *RH*, robotic hysterectomy; *VH*, vaginal hysterectomy.

[a] Mean (standard deviation), median (range), mean alone, or range alone.

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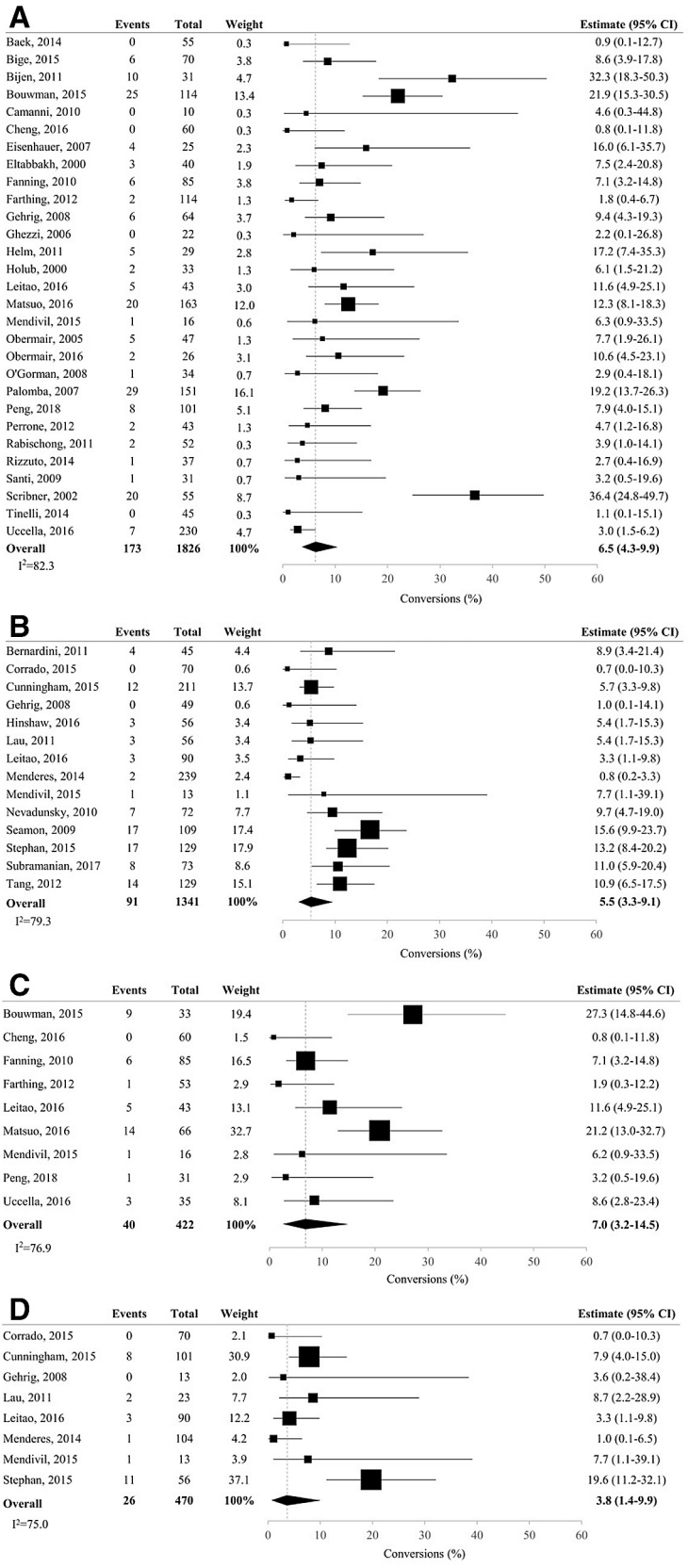
among 1341 patients with RH (14 studies).[44,52–54,59,63,65,66,69–71,83–85] In a sensitivity analysis that removed 9 studies that excluded patients with risk factors for conversion,[39,45,53,56,60,76,78,79,86] the pooled proportions were 7.3% (95% CI, 4.5–11.8) for LH and 6.3% (95% CI, 4.0–9.7) for RH (data not shown). In a subgroup analysis of patients with BMI of ≥40 kg/m$^2$, the pooled proportions of conversion were 7.0% (95% CI, 3.2–14.5) for LH and 3.8% (95% CI, 1.4–9.9) for RH (Figure 2). This corresponded to 40 events among 422 patients with LH (9 studies)[40,48,51,57,58,66,68,70,87] and 26 events among 470 patients with RH (8 studies).[53,54,59,65,66,69,70,83]

There was considerable across-study heterogeneity for this outcome ($I^2$: 82% LH; 79% RH). The proportions for single studies ranged from 0.8–36.4% (interquartile range, 3.0–11.6) for LH and 0.7–15.6% (interquartile range, 4.3–10.3) for RH. However, we could not identify a study-level cause (eg, year of publication, country, single or multicenter, sample size) that could be explored in further subgroup analyses or metaregression.

Reasons for conversion to laparotomy were documented qualitatively in 91 of 173 LH conversions (53%; 16 studies)[39,45,49,55–58,62,64,70,72–74,76,79,82] and 51 of 91 RH conversions (56%; 8 studies).[44,63,65,69–71,83,85] The most common cause of conversion was inadequate exposure because of adhesions/visceral adiposity for both LH (29/91; 32%) and RH (31/51; 61%; Table 2). Notably, 17 of 31 RH conversions for this indication occurred after hysterectomy and pelvic lymphadenectomy to allow completion of paraaortic lymphadenectomy; this was not described for any of the equivalent LH conversions.

After inadequate exposure from adhesions/adiposity, a greater proportion of LH conversions were due to anesthetic indications that were related to intolerance of the Trendelenburg position (LH 31% vs RH 6%) or organ/vessel injury (LH 21% vs RH 6%; Table 2). In contrast, a lower proportion of LH conversions were due to uterine size (LH 8% vs RH 20%; Table 2). One study

**FIGURE 2**
**Pooled proportions of conversion to laparotomy**




Pooled proportions of conversion to laparotomy from **A,** laparoscopic hysterectomy and **B,** robotic hysterectomy in patients with body mass index of ≥30 kg/m$^2$ and from **C,** laparoscopic hysterectomy and **D,** robotic hysterectomy in patients with body mass index of ≥40 kg/m$^2$. The point estimates for individual studies are based on the crude proportions that were reported by the authors. The *size of solid squares* represents statistical weights; the *grey dotted line* represents overall pooled proportion.

*CI*, confidence interval.

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specified that their 3 conversions for uterine size were in fact mini-laparotomies for specimen removal,[65] but this information could not be ascertained from any other studies.

### Perioperative complications

Results of the meta-analysis for perioperative complications are presented in Figures 3 and 4. The pooled proportion of patients who required blood transfusion was 2.8% (95% CI, 1.5−5.1) for LH and 2.1% (95% CI, 1.2−3.8) for RH. This corresponded to 47 events among 1133 patients with LH (18 studies)[39,40,42,45,50,51,56,58,60,66,70,73,75,77,79,81,82,86,87] and 16 events among 743 patients with RH (11 studies).[44,52,53,63,65,66,70,71,83−85] The proportions for single studies ranged from 1.1−25.7% for LH and 0.6−4.7% for RH.

The pooled proportion of patients who experienced an organ/vessel injury was 3.5% (95% CI, 2.2−5.5) for LH and 1.2% (95% CI, 0.4−3.4) for RH. This corresponded to 51 events among 1164 patients with LH (18 studies)[39,40,42,45,46,51,58−60,64,70,73,76,77,79,82,86,87] and 14 events among 709 patients with RH (9 studies).[44,52−54,59,65,70,83,85] The proportions for single studies ranged from 1.3−11.9% for LH and 0.5−7.0% for RH.

The pooled proportion of patients who experienced a postoperative VTE was 0.5% (95% CI, 0.2−1.2) for LH and 0.5% (95% CI, 0.1−2.0) for RH. This corresponded to 5 events among 1015 patients with LH (14

**TABLE 2**
**Documented reasons for conversion from minimally invasive to open approach**

| Variable | Laparoscopic to open | Robotic to open |
|---|---|---|
| Total conversions, n | 173 | 91 |
| Reasons not documented, n (%) | 82 (47.4) | 40 (44.0) |
| Reasons documented, n (%) | 91 (52.6) | 51 (56.0) |
| Anesthetic indication related to intolerance of the Trendelenburg position | 28 (30.8) | 3 (5.9) |
| Organ/vessel injury | 19 (20.9) | 3 (5.9) |
| Advanced/metastatic disease | 7 (7.7) | 2 (3.9) |
| Inadequate exposure because of adhesions/visceral adiposity | 29 (31.9) | 31 (60.8) |
| Uterine size | 7 (7.7) | 10 (19.6) |
| Equipment malfunction | 1 (1.1) | 2 (3.9) |

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studies)[40,42,45,46,58,62,64,67,72,76,77,79,82,87] and 2 events among 388 patients with RH (5 studies).[44,52,65,71,85] The proportions for single studies ranged from 0.4−3.2% for LH and 0.5−1.8% for RH.

### Risk of bias

We assessed all full-text articles for methodologic quality (Appendices 4 and 5). Of the double-arm studies, 79% (23/29) were at low risk of bias, and 21% (6/29) were at moderate risk of bias. Moderate risk comparative studies were deemed primarily as such for failing to control or adjust for important covariates; other limitations included drawing the comparator group from a different time or place than the exposed group and inadequate or unclear follow-up duration. Even among comparative studies at low risk of bias based on their overall Newcastle-Ottawa Quality Assessment Scale score, almost 50% of these (11/23) failed to control for any covariates. Although we extracted proportions from the minimally invasive arms only, these issues illustrate the bias likely introduced when patients were selected for one surgical approach over another.

Of the single-arm studies, 41% (9/22) were at low risk of bias, and 59% (13/22) were at moderate risk of bias. Moderate risk single-arm studies generally were deemed as such because of retrospective designs and inadequate description of patient characteristics, again underscoring the likelihood of selection bias. Additional limitations included a lack of methodologic or statistical details and inadequate or unclear follow-up duration.

The funnel plots for our primary outcome were asymmetric, which indicates that small studies with high proportions of patients who require conversion to laparotomy were not represented in the literature (Appendix 6). However, this pattern was similar for both LH and RH, which suggests that publication bias may have affected the magnitude of our pooled estimates but may have had less impact on differences between approaches.

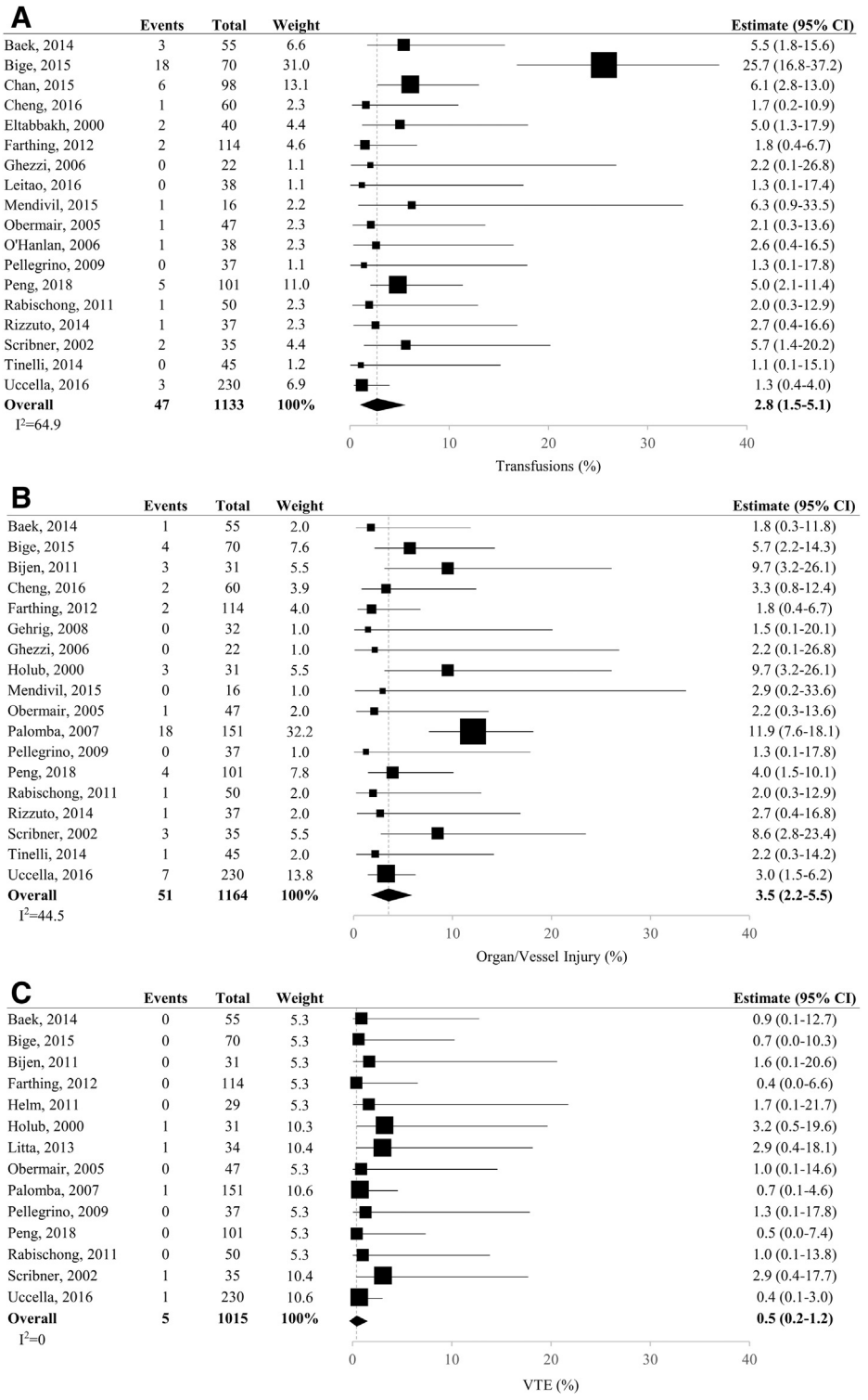
## Comment

We performed a systematic review and meta-analysis examining rates of conversion to laparotomy and other complications in patients with endometrial cancer and obesity who underwent LH or RH. Previous systematic reviews compared these outcomes across classes of obesity without consideration of the underlying surgical approach[26,48] or among women of any BMI[16−18,25,27−29]; our review is the first to quantify conversions and complications after LH or RH specifically in patients with obesity, which is a growing population for whom conventional laparoscopy is challenging and thus the comparison of LH to RH is particularly relevant.

We found that the proportions of patients with BMI $\geq$30 kg/m$^2$ who experienced conversion, blood transfusion, organ/vessel injury, and VTE were comparable whether LH or RH was performed. However, the proportion of patients with BMI $\geq$40 kg/m$^2$ who experienced conversion appeared to be higher for LH compared with RH. Qualitatively, the reasons for conversion from each approach were also different: after inadequate exposure because of adhesions/visceral adiposity, LH conversions were more often attributed to obesity-related anesthetic indications, whereas RH conversions were more often attributed to uterine size.

Although minimally invasive hysterectomy is the recommended approach for women with endometrial cancer,[3−10] adoption is difficult among patients with obesity, especially when lymphadenectomy has been required.[24,88] Several features of robotic surgery, such as 3-dimensional visualization and greater range of motion, may facilitate the completion of hysterectomy by a minimally invasive approach. However, robotic surgery comes at a direct cost of $2.6 million USD per console and $2000 USD per case.[89] Simultaneously, studies and systematic reviews of largely normal weight or overweight cohorts have been unable to illustrate improved safety or efficacy of RH compared with LH.[16−18] The high cost of RH may be justified if clinical benefits over conventional LH can be demonstrated in specific populations; for instance, there is evidence cost neutralization with the robot when it decreases laparotomy rates.[90] Patients with obesity, who have particularly high rates of laparotomy and perioperative complications after open surgery,[1,50] may be one population in which such benefits are observed. This systematic review is the first to address directly whether RH offers any benefit over LH specifically among patients with endometrial cancer and obesity.

**FIGURE 3**
**Pooled proportion of laparoscopic hysterectomy**




Pooled proportion of patients who underwent laparoscopic hysterectomy with **A,** perioperative blood transfusion, **B,** organ/vessel injury, and **C,** venous thromboembolism. The point estimates for individual studies are based on the crude proportions that were reported by the authors. The *size of solid squares* represents statistical weights; the *grey dotted line* represents overall pooled proportion.

*CI*, confidence interval; *VTE*, venous thromboembolism.

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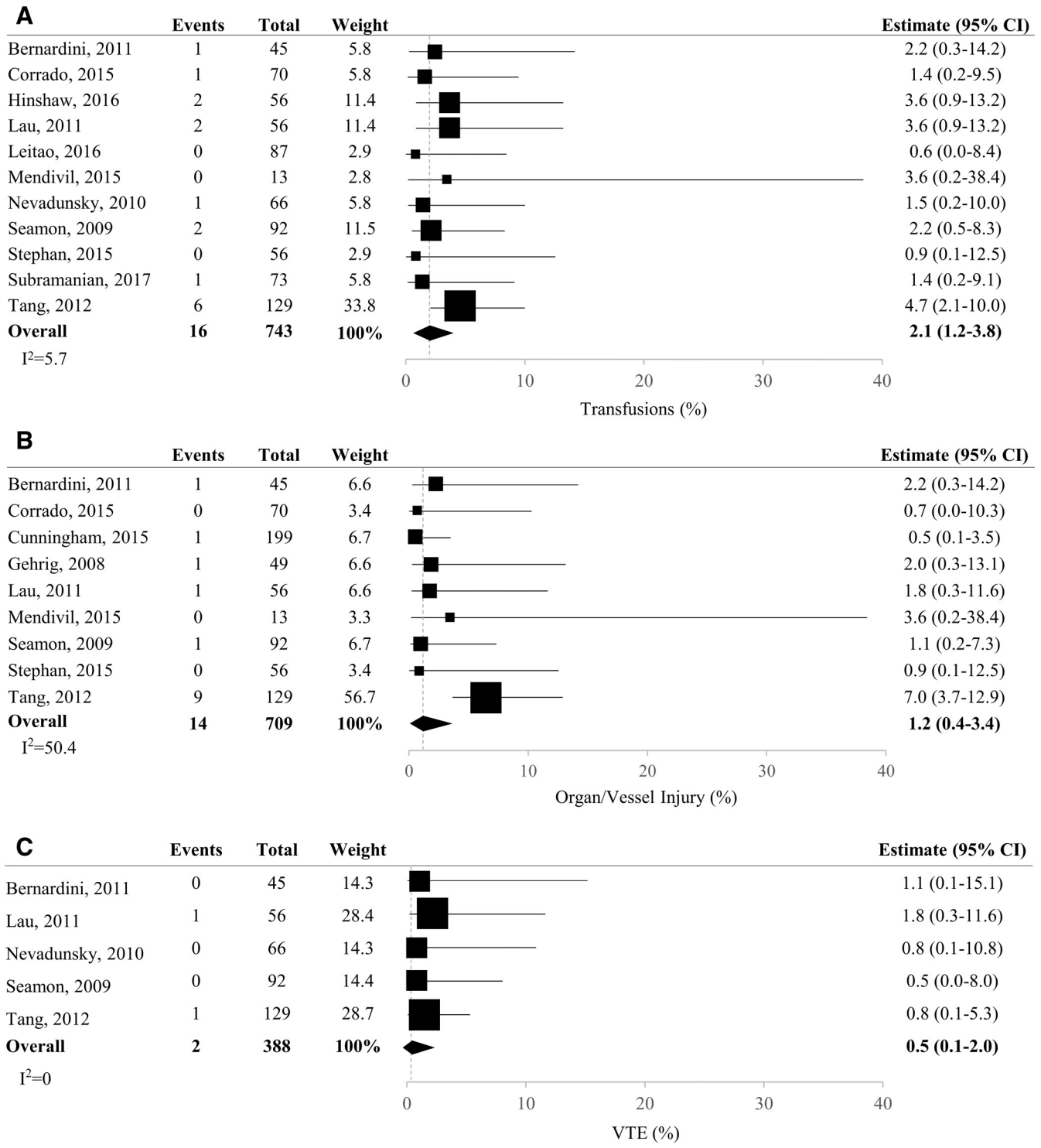
**FIGURE 4**
**Pooled proportion of robotic hysterectomy**




Pooled proportion of patients who underwent robotic hysterectomy with **A,** perioperative blood transfusion, **B,** organ/vessel injury, and **C,** venous thromboembolism. The point estimates for individual studies are based on the crude proportions that were reported by the authors. The *size of solid squares* represents statistical weights; the *grey dotted line* represents overall pooled proportion.

*CI*, confidence interval; *VTE*, venous thromboembolism.

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Our primary outcome was conversion to laparotomy, based on the hypothesis that the technologic benefits of the robot should facilitate hysterectomy in patients with obesity, and avoid the need to convert to an open operation. We saw no appreciable differences in conversion from LH and RH in patients with BMI of $\geq$30 kg/m$^2$, both in our analysis of all studies (6.5% vs 5.5%) and in a sensitivity analysis (7.3% vs 6.3%), excluding studies at risk of selection bias. However, we did see a higher proportion of conversions from LH relative to RH in patients with BMI of $\geq$40 kg/m$^2$ (7.0% vs 3.8%). Although heterogeneity was notable and the meta-analytic approach used in this study does not permit direct statistical comparisons between LH and RH, this difference is physiologically plausible and consistent with our data on the underlying reasons for conversion. More than 30% of LH conversions were due to obesity-related anesthetic indications vs only 6% of RH conversions. This suggests a potential benefit of robotic surgery in the setting of morbid obesity and aligns with the ability of robotic arms to tent the weight of the abdominal wall and enable reductions in intraperitoneal/intrathoracic pressures.[91] Because reasons for conversions were documented in just over 50% of such events and compiled here qualitatively, additional research is required to confirm this hypothesis.

It is difficult to compare the rate of conversions that were seen in our review of patients with obesity to the proportions that were seen in previous studies that were composed largely of patients with normal or slightly increased weight. Major differences other than the BMI of participants, such as the study design (randomized/observational), requirements for pelvic or paraaortic lymphadenectomy, and experience or skill of individual surgeons, influence the conversion rates that were observed and limit any direct comparisons. For example, 4 randomized trials that compared LH and RH among patients with benign disease (mean BMI, 25.7−31.4 kg/m$^2$) had only 3 instances of conversion to laparotomy combined (0.9%; 3/326), with all 3 occurring in patients randomly assigned to LH.[18] In contrast, a systematic review of observational studies that compared RH and LH (mean BMI, 27.0−34.2 kg/m$^2$) found conversion rates that ranged from 0−12% for RH and 1−26% for LH.[29] The Gynecologic Oncology Group LAP2 trial of LH vs open hysterectomy for the treatment of endometrial cancer, which had a median BMI of only 28 kg/m$^2$ but mandated paraaortic lymphadenectomy, found a 25% conversion rate.[8] Our review does not answer the question of whether conversion rates from LH or RH are higher in patients with obesity compared with patients of normal weight; rather, it summarizes existing literature on these approaches in patients with obesity and provides pooled estimates that can be referenced when discussing the risk of conversion preoperatively. We calculated similarly useful pooled estimates for blood transfusion, organ/vessel injury, and VTE. We found the rates of these perioperative complications to be low in this patient population, regardless of whether LH or RH was performed.

This systematic review was both well-designed and rigorously performed. To our knowledge, it is the first review to compare LH and RH specifically in the context of obesity, which now affects >50% of patients with a diagnosis of endometrial cancer who are seen by gynecologic surgeons. In contrast to other systematic reviews on similar topics, we selected a meta-analytic approach that allowed us to use the full breadth of data that were identified, both single arm and double arm in nature. By pooling proportions, which reflect absolute risk, we derived estimates that are useful for counselling by surgeons and interpretation by patients.

This systematic review is limited primarily by the heterogeneity and observational design of included studies. Although no studies were graded as being at a high risk of bias in our formal quality assessment, they remain susceptible to substantial selection bias. Patients chosen for LH and RH are likely different with respect to body habitus, medical/surgical history, and disease status. The skill level and preference of individual surgeons who make these decisions presumably vary as well. Few studies adequately described or accounted for these details. Notably, although all 51 studies specifically included patients with BMI of $\geq$30 kg/m$^2$, only 29 studies (57%) provided the mean or median BMI for their cohort, and most did not adjust for BMI in their analyses. Because patients with morbid obesity (BMI, $\geq$40 kg/m$^2$) are often chosen for RH rather than LH,[1] selection bias likely impacted the findings that were observed. Our data on the reasons for conversion further illustrate the broader issue of selection bias. For instance, assessments of uterine size and the degree of adhesions/adiposity are not functions of surgical approach, yet we noted a greater proportion of RH conversions for these indications, which suggests either misclassification of conversions (eg, mini-laparotomy for specimen retrieval recorded as conversion) or selection bias in that surgeons choose robotic surgery for more challenging cases with larger uteri.

Our review is also limited in its ability to compare outcomes after LH or RH among women from the highest BMI classes. Only 6 studies identified in our review described a subset of patients with BMI of $\geq$50 kg/m$^2$ [41,53,61,69,80,83]; 5 studies included patients who underwent RH; 1 study included patients who underwent LH, and 3 studies reported on conversions (0/28[69]; 1/10[53]; 11/56[83]). In the setting of supermorbid obesity (BMI, $\geq$50 kg/m$^2$), both performing hysterectomy and maintaining intraoperative ventilation/positioning are exceedingly difficult for surgeons and anesthetists, respectively. Given our findings that robotic surgery may reduce conversions in patients with BMI of $\geq$40 kg/m$^2$, particularly those related to anesthetic indications and intolerance of the Trendelenburg position, it is possible that this approach may offer the greatest value among patients with supermorbid obesity.

In conclusion, our review of moderate quality observational data suggests that LH and RH have similar rates of conversion to laparotomy and selected

perioperative complications in patients with endometrial cancer and obesity. However, RH may offer benefit specifically in patients with morbid obesity by reducing conversions because of positional intolerance. Given the influence of selection and confounding bias, randomized trials in this patient population are needed to confirm our results and direct practice standards in this high-risk patient population. ■


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## Supplementary Material

### APPENDIX 1
### Sample search strategy (MEDLINE)

1 Uterine Neoplasms/ (40505)
2 exp Endometrial Neoplasms/ (19707)
3 (endometri* adj5 (cancer* or neoplas* or tumo?r* or carcinoma* or malignan*)).tw,kf. (30746)
4 (uterus adj5 (cancer* or neoplas* or tumo?r* or carcinoma* or malignan*)).tw,kf. (7896)
5 (uterine adj (cancer* or neoplas* or tumo?r* or carcinoma* or malignan*)).tw,kf. (8431)
6 1 or 2 or 3 or 4 or 5 (74305)
7 exp Laparoscopy/ (87496)
8 Laparotomy/ (18136)
9 ((lap* adj3 assit*) or (lap* adj3 vaginal*)).tw,kf. (1761)
10 (laparoscop* or laparot* or microlaparoscop* or minilaparoscop* or microsurg* or robot* or da Vinci or davinci or AESOP or Zeus).tw,kf. (195335)
11 exp Surgery, Computer-Assisted/ (17600)
12 (LH or LAVH or TAH or TLH or LSH).tw,kf. (54229)
13 surg*.tw,kf. (1771696)
14 exp Hysterectomy/ (29289)
15 (hysterectom* or HE).tw,kf. (198788)
16 Ovariectomy/ (24184)
17 (ovariectom* or oophorectom* or female castration*).tw,kf. (35371)
18 salpingectomy/ (972)
19 (salpingectom* or tubal excision* or tubectom*).tw,kf. (1938)
20 exp Lymph Node Excision/ (43662)
21 lymphadenectom*.tw,kf. (15599)
22 ((fallopian tube* or ovar* or lymph node* or uterus or uterine or cervix or vagina) adj (excis* or remov*)).tw,kf. (2797)
23 or/7-22 (2128325)
24 exp body fat distribution/ or body mass index/ or ideal body weight/ or exp overweight/ or exp obesity/ or thinness/ or exp waist circumference/ or waist-height ratio/ or skinfold thickness/ or waist-hip ratio/ or exp Adipose Tissue/ or obesity hypoventilation syndrome/ or obesity, abdominal/ or obesity, metabolically benign/ or obesity, morbid/ or prader-willi syndrome/ or overweight/ (330786)
25 (BMI or weight or overweight or skinfold thickness or waist hip ratio* or waist-hip ratio* or adipos* or obes* or body mass ind*).tw,kf. (1069815)
26 ((abodom* or subcutaneous or intra-abdmon* or viscerel or retroperitoneal or retro peritoneal) adj3 fat*).tw,kf. (10517)
27 24 or 25 or 26 (1151484)
28 6 and 23 and 27 (1571)
29 Case Reports/ (1935014)
30 Letter/ (994263)
31 Editorial/ (453469)
32 29 or 30 or 31 (3178028)
33 28 not 32 (1412)
34 33 not (animals/ not humans/) (1362)
35 limit 34 to yr="2000 -Current" (1102)

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## APPENDIX 2
## Baseline characteristics and additional outcomes for cohorts of included studies

| First author | Body mass index, kg/m$^2$ | Type of hysterectomy | Sample size, n | Age[a] | Type I histology, n (%) | Final stage, n (%) | | Previous laparotomy, n (%) | Any lymphadenectomy, n (%) | Operating room time,[a] min | Estimated blood loss,[a] mL | Length of hospital stay,[a] d | Wound complication, n (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | I–II | III–IV | | | | | | |
| Backes | 30–40 | RH | 203 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | 40–50 | RH | 115 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | >50 | RH | 62 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Baek | ≥28 | LH | 55 | 51.5 (11.4) | 47 (85) | 52 (95) | 3 (5) | 11 (20) | 45 (82) | 184.5 (51.2) | 261.6 (401.1) | 8.2 (7.2) | NR |
| Bennich | 30–39.9 | LH | 75 | NR | NR | NR | NR | NR | 34 (45) | 33–210 | 15–450 | 1 (0–3) | NR |
| | ≥40 | LH | 22 | NR | NR | NR | NR | NR | 9 (41) | 45–230 | 50–300 | 1 (0–7) | NR |
| Bernardini | ≥35 | OH | 41 | 62 (31–86) | 33 (80) | 32 (78) | 9 (22) | 20 (49) | 14 (34) | 165 (75–295) | 300 (100–350) | 4 (2–21) | 2 (5) |
| | | RH | 45 | 61 (36–87) | 37 (82) | 34 (78) | 10 (22) | 17 (38) | 16 (36) | 270 (135–470) | 200 (50–1500) | 2 (1–24) | 0 |
| Bige | ≥35 | OH | 70 | 56.24 (10.55) | 63 (90) | 68 (97) | 2 (3) | 19 (27) | 70 (100) | 185.94 (30.26) | 438.29 (271.97) | 10.36 (5.69) | 8 (11) |
| | | LH | 70 | 55.56 (10.62) | 64 (91) | 67 (96) | 3 (4) | 24 (34) | 70 (100) | 155.03 (37.68) | 561.86 (341.55) | 4.64 (4.68) | 1 (1) |
| Bijen | >35 | OH | 24 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 3 (13) |
| | | LH | 31 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 3 (10) |
| Borgfeldt | ≥35 | OH | 358 | NR | NR | NR | NR | NR | 79 (22) | 139.6 (49.6) | 154.0 (303.0) | 2.3 (1.1) | NR |
| | | LH | 32 | NR | NR | NR | NR | NR | 1 (3) | 115.3 (45.4) | 72.1 (64.1) | 1.7 (0.7) | NR |
| | | RH | 63 | NR | NR | NR | NR | NR | 28 (44) | 201.6 (56.1) | 100.0 (78.9) | 2.0 (1.5) | NR |
| Bouwman | 30–39.9 | OH | 110 | NR | NR | NR | NR | NR | NR | NR | 290 (272.7) | NR | NR |
| | | LH | 81 | NR | NR | NR | NR | NR | NR | NR | 116 (110.6) | NR | NR |
| | ≥40 | OH | 36 | NR | NR | NR | NR | NR | NR | NR | 258 (200.8) | NR | NR |
| | | LH | 33 | NR | NR | NR | NR | NR | NR | NR | 125 (92.6) | NR | NR |
| | | | | | | | | | | | | | |
| Camanni | ≥30 | LH | 10 | 63 (6.5) | NR | NR | NR | 6 (60) | NR | 178 (49) | NR | Reported in hours | NR |
| Chan | ≥40 | OH | 567 | 59 (27–89) | NR | NR | NR | NR | 196 (35) | NR | NR | 4 | 17 (3) |
| | | LH | 98 | 61 (32–87) | NR | NR | NR | NR | 18 (18) | NR | NR | 1 | 1 (1) |
| | | RH | 422 | 60 (22–84) | NR | NR | NR | NR | 127 (30) | NR | NR | 1 | 4 (0.9) |
| Cheng | >40 | OH | 60 | 62 (39–84) | 60 (100) | 60 (100) | 0 | 9 (15) | NR | 261 (155–400) | 188.2 (100–1000) | 11 (7–17) | NR |
| | | LH | 60 | 61 (40–87) | 60 (100) | 60 (100) | 0 | 10 (17) | NR | 235 (160–360) | 100.7 (30–500) | 6 (4–7) | NR |

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(continued)

## APPENDIX 2

### Baseline characteristics and additional outcomes for cohorts of included studies *(continued)*

| First author | Body mass index, kg/m$^2$ | Type of hysterectomy | Sample size, n | Age[a] | Type I histology, n (%) | Final stage, n (%) | | Previous laparotomy, n (%) | Any lymphadenectomy, n (%) | Operating room time,[a] min | Estimated blood loss,[a] mL | Length of hospital stay,[a] d | Wound complication, n (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | I–II | III–IV | | | | | | |
| Cohn | ≥30 | OH | 191 | 62 (11.5) | NR | NR | NR | 120 | 138 | 394 | 143 (47) | 3 (3–4) | 28 |
| | | RH | 109 | 58 (10.0) | NR | NR | NR | 55 | 80 | 109 | 228 (43) | 1 (1–2) | 2 |
| Corrado | 40–45 | RH | 50 | 60 (36–81) | 41 (82) | 44 (88) | 6 (12) | 26 (52) | 22 (44) | 162.5 (60–520) | 75 (10–400) | 3 (2–10) | 1 (2) |
| | 45–50 | RH | 10 | 63 (30–78) | 10 (100) | 10 (100) | 0 | 7 (70) | 3 (30) | 160 (80–330) | 87.5 (20–200) | 2 (2–4) | 0 |
| | >50 | RH | 10 | 62 (41–77) | 8 (80) | 8 (80) | 2 (2) | 4 (40) | 2 (20) | 177.5 (85–630) | 50 (50–300) | 3 (2–12) | 0 |
| Cunningham | 30–39 | RH | 110 | 64.20 (34–90) | NR | NR | NR | NR | 100 (91) | 119.14 | NR | 1.03 | NR |
| | ≥40 | RH | 101 | 59.86 (32–79) | NR | NR | NR | NR | 78 (77) | 129.6 | NR | 1.08 | NR |
| Eisenhauer | ≥35 | OH | 154 | 60 (25–84) | 131 (85) | 142 (92) | 12 (8) | NR | 69 (45) | 40–368 | 40–2200 | 6 (4–56) | 54 (35) |
| | | LH | 25 | 57 (35–79) | 23 (92) | 25 (100) | 0 | NR | 10 (40) | 94–330 | 50–500 | 3 (2–7) | 2 (8) |
| Eltabbakh | 28–60 | OH | 40 | 61.3 (13.2) | 29 (73) | 38 (97.5) | 1 (2.5) | 16 (40) | 32 (80) | 137.7 (43.4) | 303.3 (198.1) | 5.6 (3.6) | 2 (5) |
| | | LH | 40 | 59.4 (11.9) | 30 (75) | 39 (100) | 0 | 14 (35) | 31 (78) | 194.8 (42.3) | 318.2 (177.0) | 2.5 (1.2) | 0 |
| Fanning | ≥40 | LH | 85 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Farthing | 30–39.99 | LH | 61 | NR | 50 (82) | NR | NR | NR | NR | 95 | 50 | 2.5 | 2 (3) |
| | ≥40 | LH | 53 | NR | 44 (83) | NR | NR | NR | NR | 75 | 50 | 2 | 1 (2) |
| Gehrig | ≥30 | LH | 32 | 61.2 (32–80) | 2 (6) | 26 (81) | 6 (19) | NR | 30 (94) | 215 (156–324) | 150 (50–700) | 1.27 (1–4) | NR |
| | | RH | 49 | 61.3 (42–90) | 43 (88) | 44 (90) | 5 (10) | NR | 46 (94) | 189 (111–263) | 50 (25–300) | 1.02 (1–2) | NR |
| Ghezzi | ≥30 | LH | 22 | NR | NR | NR | NR | NR | 22 (100) | 209 (49.1) | 165 (50–400) | 3 (2–6) | NR |
| Giugale | ≥30 | OH | 379 | 57.8 | NR | I=259 (68) | NR | NR | 167 (44) | NR | 365.7 | NR | 174 (46) |
| | | LH/RH | 280 | 58.6 | NR | I=215 (77) | NR | NR | 156 (56) | NR | 173.9 | NR | 104 (37) |
| Helm | ≥36 | OH | 56 | NR | NR | I=48 (85) | NR | NR | 20 (36) | NR | NR | NR | NR |
| | | LH | 29 | NR | NR | I=26 (90) | NR | NR | 5 (17) | NR | NR | NR | NR |
| Hinshaw | ≥35 | OH | 80 | 61.5 | NR | 68 (85) | 12 (15) | NR | 72 (90) | 200 | 338 | 4 | 7 (9) |
| | | RH | 56 | 61.5 | NR | 49 (88) | 7 (12) | NR | 49 (88) | 212 | 150 | 1 | 2 (4) |
| Holub | ≥30 | LH | 33 | 57.45 (47–67) | 29 (88) | 29 (88) | 4 (12) | NR | 26 (79) | 166.14 | 242.6 (50–1600) | 5.3 (3–10) | 1 (3) |

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## APPENDIX 2

### Baseline characteristics and additional outcomes for cohorts of included studies *(continued)*

| First author | Body mass index, kg/m$^2$ | Type of hysterectomy | Sample size, n | Age[a] | Type I histology, n (%) | Final stage, n (%) | | Previous laparotomy, n (%) | Any lymphadenectomy, n (%) | Operating room time,[a] min | Estimated blood loss,[a] mL | Length of hospital stay,[a] d | Wound complication, n (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | I–II | III–IV | | | | | | |
| Lau | 30–39.9 | RH | 33 | 66.9 (10.3) | 26 (79) | 30 (91) | 3 (9) | 18 (55) | 33 (100) | 255 (64) | 95.9 (102.9) | 2 (1–44) | 5 (15) |
| | ≥40 | RH | 23 | 54.7 (9.5) | 19 (83) | 21 (96) | 1 (4) | 9 (39) | 23 (100) | 257 (39) | 94 (72.4) | 2 (1–6) | 2 (9) |
| Leitao | ≥40 | OH | 299 | NR | NR | NR | NR | NR | NR | 170 (40–419) | 250 (50–3000) | 5 (2–37) | 86 (29) |
| | | LH | 43 | NR | NR | NR | NR | NR | NR | 190 (89–344) | 100 (25–900) | 2 (1–7) | 9 (LH+RH) (21) |
| | | RH | 90 | NR | NR | NR | NR | NR | NR | 193 (87–448) | 50 (5–800) | 1 (0–5) | |
| Litta | ≥30 | LH | 34 | 66.32 (6.17) | 34 (100) | 33 (97) | 1 (3) | NR | 34 (100) | 197.05 (9.17) | 62.37 (74.09) | 3.16 (1.214) | NR |
| Mahdi | 30–39.99 | OH | 763 | NR | NR | NR | NR | NR | NR | 72.6 | NR | 4.4 | NR |
| | | LH | 733 | NR | NR | NR | NR | NR | NR | 193.9 | NR | 1.5 | NR |
| | ≥40 | OH | 541 | NR | NR | NR | NR | NR | NR | 78.6 | NR | 5.1 | NR |
| | | LH | 400 | NR | NR | NR | NR | NR | NR | 201.8 | NR | 1.7 | NR |
| Matsuo | 30–39.9 | LH | 97 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | ≥40 | LH | 66 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Menderes | 30–39.99 | RH | 135 | 64.4 (9.4) | 77 (57) | 110 (81) | 25 (19) | NR | NR | 162.6 (59) | 120.2 (132.1) | 1.59 (2.22) | NR |
| | 40–49.99 | RH | 76 | 61.6 (8.7) | 68 (89) | 68 (89) | 8 (11) | NR | NR | 154.1 (49.2) | 117.1 (83.2) | 1.89 (3.1) | NR |
| | ≥ 50 | RH | 28 | 58.1 (10.4) | 28 (100) | 23 (82) | 5 (18) | NR | NR | 188.95 (50.0) | 152.7 (95.8) | 2.07 (1.2) | NR |
| Mendivil | >40 | OH | 24 | 58 (30–71) | 18 (75) | 20 (83) | 4 (17) | NR | 24 (100) | 81 (55.2–160.2) | 250 (50–1000) | 4 (2–25) | 0 |
| | | LH | 16 | 59 (35–78) | 12 (75) | 16 (100) | 0 | NR | 16 (100) | 109.2 (66–235.2) | 175 (24–700) | 2 (1–4) | 1 (6) |
| | | RH | 13 | 54 (37–65) | 9 (69) | 13 (100) | 0 | NR | 13 (100) | 166.8 (85.2–265.2) | 100 (50–150) | 2 (1–3) | 0 |
| Nevadunsky | ≥30 | OH | 43 | 60 (39–86) | 32 (74) | 36 (84) | 6 (16) | 19 (44) | 24 (56) | 134 (72–258) | 193 (0–1000) | 3.8 (1–14) | 8 (19) |
| | | RH | 66 | 62 (35–89) | 56 (85) | 60 (91) | 6 (8) | 34 (52) | 43 (65) | 204 (127–379) | 83 (10–400) | 1.3 (1–4) | 0 |
| Obermair | ≥100kg | OH | 31 | 56.9 (9.6) | 29 (94) | 28 | 3 (10) | NR | 12 (39) | 126.8 (44.6) | 319.8 (239.8) | 7.9 (3.0) | 15 (48) |
| | | LH | 47 | 546 (13.4) | 46 (98) | 45 (96) | 2 (4) | NR | 7 (15) | 139.3 (50.6) | 278.5 (556.7) | 4.4 (3.9) | 3 (6) |
| Obermair | >30 | LH | 26 | 68.5 (40–86) | 25 (96) | 25 (96) | 1 (4) | NR | NR | NR | NR | 2(1–28) | NR |
| O'Gorman | ≥30 | LH | 34 | 32–84 | 29 (85) | 34 (100) | 0 | 4 (12) | NR | NR | NR | 4 (3–7) | NR |
| O'Hanlan | 30–39.9 | LH | 26 | NR | NR | NR | NR | NR | NR | 152.6 | 156 | 1.7 | NR |
| | ≥40 | LH | 12 | NR | NR | NR | NR | NR | NR | 145.6 | 101.7 | 1.2 | NR |

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*(continued)*

## APPENDIX 2

### Baseline characteristics and additional outcomes for cohorts of included studies *(continued)*

| First author | Body mass index, kg/m$^2$ | Type of hysterectomy | Sample size, n | Age[a] | Type I histology, n (%) | Final stage, n (%) | | Previous laparotomy, n (%) | Any lymphadenectomy, n (%) | Operating room time,[a] min | Estimated blood loss,[a] mL | Length of hospital stay,[a] d | Wound complication, n (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | I–II | III–IV | | | | | | |
| Palomba | >30 | LH | 122 | 62 (interquartile range, 45–80) | 92 (75) | 121 (99) | 2 (1) | 52 (43) | 122 (100) | NR | NR | NR | 0 |
| Pellegrino | >30 | OH | 37 | NR | NR | NR | NR | NR | 21 (57) | 170 (90–300) | 490 (200–1400) | 5 (5–30) | 4 (11) |
| | | LH | 37 | NR | NR | NR | NR | NR | 24 (65) | 228 (120–360) | 188 (100–300) | 4 (3–6) | 0 |
| Peng | 30–39.9 | LH | 70 | 67.0 (10.3) | NR | 55 (79) | 15 (21) | NR | 49 (70) | 185 (89) | 191 (214) | NR | 4 (6) |
| | ≥40 | LH | 31 | 62.5 (11.4) | NR | 27 (87) | 4 (13) | NR | 16 (52) | 181 (65) | 119 (90) | NR | 2 (6) |
| Perrone | ≥30 | OH | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | | LH | 43 | 65.4 (8.5) | NR | NR | NR | NR | NR | 269.4 (86.8) | NR | 3.4 (1.1) | NR |
| Rabischong | ≥30 | LH | 52 | 63.4 (7.6) | NR | 46 (92) | 4 (8) | NR | 35 (67) | 187.5 (47.9) | NR | 5.2 (2.07) | NR |
| Ramzan | ≥50 | OH | 20 | 49.2 (11.8) | 19 (95) | 15 (75) | 5 (25) | NR | NR | 272 (136) | 603 (451) | 4 (3–11) | NR |
| | | LH | 20 | 55.4 (5.8) | 20 (100) | 19 (95) | 1 (5) | NR | NR | 307 (116) | 294 (237) | 2 (1–11) | NR |
| Rizzuto | ≥30 | LH | 37 | NR | NR | NR | NR | NR | NR | 91.7 (55–180) | 288.1 (150–550) | 2.44 (1–7) | NR |
| Santi | 30–35 | OH | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | | LH | 13 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | >35 | OH | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| | | LH | 18 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Scribner | ≥28 | OH | 45 | 58.4 (31–85) | NR | 38 (84) | 7 (16) | 22 (49) | 45 (100) | 140.7 | 344.2 | 4.5 | 10 (22) |
| | | LH | 55 | 64.6 (25–92) | NR | 46 (85) | 8 (15) | 24 (44) | 35 | 265.3 | 361.8 | 2.8 | 5 (9) |
| Stephan | ≥50 | RH | 56 | 56.17 | 54 (96) | 54 (96) | 2 (4) | 30 (54) | 42 (75) | 269.1 | 150.0 | 2.1 | 7 (13) |
| Subramaniam | ≥30 | OH | 104 | 61.3 (10.8) | 64 (62) | NR | NR | NR | 59 (57) | 138.2 (53.4) | 408.9 (290.3) | 5.07 (2.54) | 21 (20) |
| | | RH | 73 | 57.0 (9.3) | 48 (66) | NR | NR | NR | 48 (66) | 246.2 (75.2) | 95.9 (109.4) | 2.73 (1.84) | 3 (4) |
| Suidan | 30–39.9 | OH | 156 | NR | NR | NR | NR | NR | NR | NR | NR | 4 (3–4) | 8(5) |
| | | LH/RH/VH | 250 | NR | NR | NR | NR | NR | NR | NR | NR | 1 (1–2) | 4(2) |
| | ≥40 | OH | 129 | NR | NR | NR | NR | NR | NR | NR | NR | 4 (3–5) | 18 (14) |
| | | LR/RH/VH | 192 | NR | NR | NR | NR | NR | NR | NR | NR | 1 (1–2) | 4 (2) |

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*(continued)*

## APPENDIX 2

### Baseline characteristics and additional outcomes for cohorts of included studies *(continued)*

| First author | Body mass index, kg/m$^2$ | Type of hysterectomy | Sample size, n | Age[a] | Type I histology, n (%) | Final stage, n (%) | | Previous laparotomy, n (%) | Any lymphadenectomy, n (%) | Operating room time,[a] min | Estimated blood loss,[a] mL | Length of hospital stay,[a] d | Wound complication, n (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | I–II | III–IV | | | | | | |
| Tang | ≥30 | OH | 110 | 58.5 (9.9) | 109 (99) | 100 (92) | 9 (8) | 59 (54) | 82 (75) | 128 (39) | 292 (226) | 4.1 (2.2) | 36 (33 |
| | | RH | 129 | 59.8 (10.6) | 127 (98) | 120 (94) | 8 (6) | 76 (59) | 97 (75) | 188 (63) | 160 (150) | 1.5 (1.0) | 18 (14) |
| Tinelli | >35 | OH | 30 | 63 (14) | NR | 27 (90) | 3 (10) | NR | 30 (100) | 143 (25) | 125+32 | 6.3 (1.1) | 3(10) |
| | | LH | 45 | 38 (7.3) | NR | 41 (91) | 4 (9) | NR | 45 (100) | 166 (21) | 65+15 | 3.1−− (0.4) | 3 (85) |
| Uccella | ≥30 | OH | 161 | NR | NR | NR | NR | NR | 85 (53) | NR | NR | 7.5 (6.2) | 14 (9) |
| | | LH | 230 | NR | NR | NR | NR | NR | 144 (63) | NR | NR | 3.3 (2.5) | 8 (3) |

*OH*, open; *LH*, laparoscopic; *NR*, not reported; *RH*, robotic; *VH*, vaginal.

[a] Data are given as mean (standard deviation) or median (range).

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**APPENDIX 3**

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**References excluded at full-text stage with reasons** *(continued)*

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*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.* *(continued)*

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*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.* *(continued)*

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**References excluded at full-text stage with reasons** *(continued)*

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| Gallotta V, Gaballa K, Conte C, et al. Robotic versus laparoscopic transperitoneal para aortic lymphadenectomy in gynecologic cancers: A single institute experience. Int J Gynecol Cancer 2017;27(suppl4):483 | Conference abstract |
| Ganju RG, Tennapel MJ, Chen AM, Hoover A. Prognostic significance of sarcopenia for patients treated by surgery and radiation for uterine cancer. Int J Radiat Oncol Biol Phys 2017;99(suppl1):E292 | Conference abstract |
| Guzel AB, Kucukgoz Gulec U, Sucu M, Khatib G, Vardar MA. Clinical and prognostic effects of obesity on endometrial cancer. Int J Gynecol Cancer 2017;27(suppl4):218 | Conference abstract |
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| Moritake T, Ito H, Takamizawa S, Isaka K. Is robotic surgery for endometrial cancer affected by patient physique? Investigation of Japanese patients. J Minim Invasive Gynecol 2017;24(suppl1):S102 | Conference abstract |
| Pletnev A, Taranenko S, Mavrichev S. Advantages of laparoscopic surgery versus open surgery in endometrial cancer-3 year single institution data. Int J Gynecol Cancer 2017;27(suppl4):452 | Conference abstract |
| Pursell N, El-Neemany D, Greenberg P, et al. Outcomes of robotic-assisted laparoscopic hysterectomy stratified by body mass index. J Minim Invasive Gynecol 2017;24(suppl1):S155 | Conference abstract |
| Centre for Reviews; Dissemination. Laparoscopy as the primary modality for the treatment of women with endometrial carcinoma (structured abstract). 2011. | Letter/review |
| Centre for Reviews; Dissemination. Laparoscopic hysterectomy is preferred over laparotomy in early endometrial cancer patients, however not cost effective in the very obese (provisional abstract). 2011 | Letter/review |
| Centre for Reviews; Dissemination. Comparison of laparoscopy and laparotomy for endometrial cancer (structured abstract). Database of abstracts of reviews of effects. 2015. | Letter/review |
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*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.* *(continued)*

**APPENDIX 3**
**References excluded at full-text stage with reasons** *(continued)*

| Reference | Reason for exclusion |
|---|---|
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| Devaja O, Samara I, Papadopoulos AJ. Laparoscopically assisted vaginal hysterectomy (LAVH) versus total abdominal hysterectomy (TAH) in endometrial carcinoma: prospective cohort study. Int J Gynecol Cancer 2010;20:570-5 | No focus on body mass index |
| Ghezzi F, Cromi A, Bergamini V, et al. Laparoscopic-assisted vaginal hysterectomy versus total laparoscopic hysterectomy for the management of endometrial cancer: a randomized clinical trial. J Minim Invasive Gynecol 2006;13:114-20 | No focus on body mass index |
| Fowler JM, Seamon LG, Cohn DE, et al. Robotic hysterectomy and pelvic-aortic lymphadenectomy for endometrial cancer. Obstet and Gynecol 2008;112:1207-13 | No focus on body mass index |
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| Ghezzi F, Cromi A, Uccella S, Giudici S, Franchi M, Bolis P. Left-right asymmetry in pelvic lymph nodes distribution: is there a right-side prevalence?. Eur J Obstet Gynecol Reprod Biol 2006;127:236-9 | No focus on body mass index |
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*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.* *(continued)*

**APPENDIX 3**
**References excluded at full-text stage with reasons** *(continued)*

| Reference | Reason for exclusion |
|---|---|
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| Loaec C, Vaucel E, Darnis E, et al. [Clinical practice for morbidly obese endometrial cancer patients: A French multicentric study]. Bulletin du Cancer 2018;105:441-9 | Not in English |
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| Umeadi UP, Ahmed AS, Murphy J, Slade RJ. Apronectomy in combination with major gynaecological procedures. J Obstet Gynaecol 2008;28:516-8 | Panniculectomy |
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| Davenport WB, Lowe MP, Chamberlin DH, et al. Outcomes of obese versus non-obese subjects undergoing robotic-assisted hysterectomy: a multi-institutional study. J Robot Surg 2013;7:15-20 | Unable to identify patients with endometrial cancer |
| Eddib A, Danakas A, Hughes S, et al. Influence of morbid obesity on surgical outcomes in robotic-assisted gynecologic surgery. J Gynecol Surg 2014;30:81-6 | Unable to identify patients with endometrial cancer |
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*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.* *(continued)*

**APPENDIX 3**
**References excluded at full-text stage with reasons** *(continued)*

| Reference | Reason for exclusion |
|---|---|
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| Canlorbe G, Bendifallah S, Raimond E, et al. Severe obesity impacts recurrence-free survival of women with high-risk endometrial cancer: results of a French multicenter study. Ann Surg Oncol 2015;22:2714-21 | Unable to identify surgical approach |
| Cote ML, Ruterbusch JJ, Ahmed Q, et al. Endometrial cancer in morbidly obese women: do racial disparities affect surgical or survival outcomes? Gynecol Oncol 2014;133:38-42 | Unable to identify surgical approach |
| Fambrini M, Pieralli A, Bitossi U, et al. Mini-laparotomy versus vaginal surgery for class II-III obese patients with early-stage endometrial cancer. Anticancer Res 2012;32:707-12 | Unable to identify surgical approach |
| Gunderson CC, Java J, Moore KN, Walker JL. The impact of obesity on surgical staging, complications, and survival with uterine cancer: a Gynecologic Oncology Group LAP2 ancillary data study. Gynecol Oncol 2014;133:23-7 | Unable to identify surgical approach |
| Kristensen AB, Hare-Bruun H, Hogdall CK, Rudnicki M. Influence of body mass index on tumor pathology and survival in uterine cancer: a Danish register study. Int J Gynecol Cancer 2017;27:281-8 | Unable to identify surgical approach |
| Linkov F, Edwards RP, Althouse A, et al. Obesity, lymphadenectomy and survival outcomes in intermediate to high-risk, early-stage endometrial cancer patients. Future Oncol 2015;11:607-15 | Unable to identify surgical approach |
| Todo Y, Okamoto K, Minobe S, Kato H. Clinical significance of surgical staging for obese women with endometrial cancer: a retrospective analysis in a Japanese cohort. Jpn J Clin Oncol 2014;44:903-9 | Unable to identify surgical approach |
| Von Gruenigen VE, Tian C, Frasure H, Waggoner S, Keys H, Barakat RR. Treatment effects, disease recurrence, and survival in obese women with early endometrial carcinoma : a Gynecologic Oncology Group study. Cancer 2006;107:2786-91 | Unable to identify surgical approach |
| Yin XH, Jia HY, Xue XR, Yang SZ, Wang ZQ. Clinical analysis of endometrial cancer patients with obesity, diabetes, and hypertension. Int J Clin Exper Med 2014;7:736-43 | Unable to identify surgical approach |
| Akbayir O, Corbacioglu Esmer A, Numanoglu C, et al. Influence of body mass index on clinicopathologic features, surgical morbidity and outcome in patients with endometrial cancer. Arch Gynecol Obstet 2012;286:1269-76 | Open hysterectomy |
| Erkanli S, Kayaselcuk F, Bagis T, Kuscu E. Impact of morbid obesity in surgical management of endometrial cancer: surgical morbidity, clinical and pathological aspects. Eur J Gynaecol Oncol 2006;27:401-4 | Open hysterectomy |
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| Martra F, Kunos C, Gibbons H, et al. Adjuvant treatment and survival in obese women with endometrial cancer: an international collaborative study. Am J Obstet Gynecol 2008;198:89.e1-8 | Open hysterectomy |
| Pavelka JC, Ben-Shachar I, Fowler JM, et al. Morbid obesity and endometrial cancer: surgical, clinical, and pathologic outcomes in surgically managed patients. Gynecol Oncol 2004;95:588-92 | Open hysterectomy |
| Santoso JT, Barton G, Riedley-Malone S, Wan JY. Obesity and perioperative outcomes in endometrial cancer surgery. Arch Gynecol Obstet 2012;285:1139-44 | Open hysterectomy |
| Everett E, Tamimi H, Greer B, et al. The effect of body mass index on clinical/pathologic features, surgical morbidity, and outcome in patients with endometrial cancer. Gynecol Oncol 2003;90:150-7 | Open hysterectomy |
| Lau S, Aubin S, Rosberger Z, et al. Health-related quality of life following robotic surgery: a pilot study. J Obstet Gynaecol Can 2014;36:1071-8 | Duplicate cohort |

*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.*

## APPENDIX 4

## Risk of bias assessment results for single-arm studies with the use of the Institute of Health Economics Quality Appraisal Checklist

| | First author, year | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Backes, 2015 | Baek, 2014 | Bennich, 2016 | Camanni, 2010 | Corrado, 2015 | Cunningham, 2015 | Fanning, 2010 | Farthing, 2012 | Ghezzi, 2006 | Holub, 2000 | Lau, 2011 | Litta, 2013 | Matsuo, 2016 | Menderes, 2014 | Obermair, 2005 | O'Gorman, 2008 | O'Hanlan, 2006 | Palomba, 2007 | Peng, 2018 | Rabischong, 2011 | Rizzuto, 2014 | Stephan, 2015 |
| Was the hypothesis/aim/objective of the study clearly stated? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Partial | Yes | Yes | Yes | Yes | Yes |
| Was the study conducted prospectively? | No | No | No | No | Yes | No | No | No | Unclear | Yes | Yes | Unclear | No | No | Yes | No | No | Yes | No | No | No | No |
| Was the cohort collected in ≥1 centre? | No | No | No | No | Yes | No | No | No | Yes | Yes | No | No | No | No | Yes | No | No | No | No | Yes | No | No |
| Were patients recruited consecutively? | Yes | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | Yes | yes | Unclear | Yes | Yes | Yes | Yes |
| Were the characteristics of the patients who were included in the study described? | Partial | Yes | Yes | Partial | Yes | Partial | Yes | Partial | Partial | Partial | Yes | Yes | Yes | Partial | Yes | Partial | Partial | Yes | Yes | Yes | Partial | Yes |
| Were the eligibility criteria (ie, inclusion and exclusion criteria) for entry into the study clearly stated? | Yes | Yes | Yes | Partial | Yes | Partial | Yes | Yes | Yes | Partial | Partial | Yes | Partial | Partial | Yes | Partial | Yes | Yes | Yes | Partial | Yes | Yes |
| Did patients enter at a similar point in the disease? | Unclear | Yes | Yes | No | Unclear | Unclear | Yes | Yes | Yes | Yes | Unclear | Yes | Unclear | Unclear | Yes | Yes | Unclear | Yes | No | Yes | No | Yes |
| Was the intervention of interest clearly described? | Partial | Partial | Yes | No | Yes | Yes | Yes | Yes | Partial | Yes | Yes | Yes | Partial | Yes | Partial | Yes | Yes | Yes | Partial | Yes | Yes | Yes |
| Were additional interventions (co-interventions) clearly described? | Partial | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Partial | Yes | Partial | Yes | Yes | Yes | Partial | Yes | No | Yes |
| Were outcome measures established a priori? | Partial | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Partial | Partial | Yes | Yes | Yes | Partial | No | No | Partial | Yes | Partial | Yes | Partial |

*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.*

*(continued)*

## APPENDIX 4

### Risk of bias assessment results for single-arm studies with the use of the Institute of Health Economics Quality Appraisal Checklist *(continued)*

| Variable | First author, year | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Backes, 2015 | Baek, 2014 | Bennich, 2016 | Camanni, 2010 | Corrado, 2015 | Cunningham, 2015 | Fanning, 2010 | Farthing, 2012 | Ghezzi, 2006 | Holub, 2000 | Lau, 2011 | Litta, 2013 | Matsuo, 2016 | Menderes, 2014 | Obermair, 2005 | O'Gorman, 2008 | O'Hanlan, 2006 | Palomba, 2007 | Peng, 2018 | Rabischong, 2011 | Rizzuto, 2014 | Stephan, 2015 |
| Were the outcome assessors blinded to the intervention that patients received? | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | No | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear |
| Were the relevant outcomes measured with appropriate objective/ subjective methods? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the relevant outcome measures made before and after the intervention? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the statistical tests that were used to assess the relevant outcomes appropriate? | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | Unclear | Yes | Yes | Yes | Yes | Yes | Yes |
| Were losses to follow up reported? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Was the follow-up period long enough for important events and outcomes to occur? | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | No | Yes | Yes | Unclear | Yes | Unclear | Unclear | Unclear | Unclear | Yes | Unclear | Yes |
| Did the study provide estimates of random variability in the data analysis of relevant outcomes? | No | Yes | Yes | Yes | Yes | Partial | Yes | Partial | Yes | Partial | Yes | Yes | Yes | Yes | Partial | Partial | Partial | Yes | Yes | Yes | No | Yes |
| Were the adverse events reported? | Yes | Yes | Yes | Yes | Yes | Yes | Partial | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.*

*(continued)*

## APPENDIX 4

### Risk of bias assessment results for single-arm studies with the use of the Institute of Health Economics Quality Appraisal Checklist *(continued)*

| Variable | First author, year | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Backes, 2015 | Baek, 2014 | Bennich, 2016 | Camanni, 2010 | Corrado, 2015 | Cunningham, 2015 | Fanning, 2010 | Farthing, 2012 | Ghezzi, 2006 | Holub, 2000 | Lau, 2011 | Litta, 2013 | Matsuo, 2016 | Menderes, 2014 | Obermair, 2005 | O'Gorman, 2008 | O'Hanlan, 2006 | Palomba, 2007 | Peng, 2018 | Rabischong, 2011 | Rizzuto, 2014 | Stephan, 2015 |
| Were the conclusions of the study supported by the results? | Yes | Yes | Yes | Yes | Unclear | Yes | Unclear | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were both competing interests and sources of support for the study reported? | Partial | Partial | Yes | No | Partial | Partial | Partial | Partial | No | No | Yes | No | Yes | Yes | Yes | No | No | Partial | Partial | Yes | Partial | Partial |
| Total quality score | 13 | 16.5 | 17.5 | 12 | 18 | 15 | 14 | 15 | 16.5 | 15.5 | 16 | 16.5 | 15.5 | 15.5 | 16 | 13 | 13 | 15.5 | 14.5 | 17.5 | 13 | 16.5 |
| Risk of bias[a] | Moderate | Low | Low | Moderate | Low | Moderate | Moderate | Moderate | Low | Moderate | Low | Low | Moderate | Moderate | Low | Moderate | Moderate | Moderate | Moderate | Low | Moderate | Low |

[a] Scoring: low, 80–100%; moderate, 60–79%; high, 0–59%.

*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.*

**APPENDIX 5**

## Risk of bias assessment results for comparative studies with the Newcastle Ottawa Scale

| First author | Selection | Comparability | Outcome | Total | Risk of bias[a] |
|---|---|---|---|---|---|
| Bernardini | ★★★ | | ★★ | 5 | Moderate |
| Bige | ★★★★ | | ★★★ | 7 | Low |
| Bijen | ★★★★ | ★ | ★★★ | 8 | Low |
| Borgfeldt | ★★★★ | ★★ | ★★ | 8 | Low |
| Bouwman | ★★★★ | | ★★★ | 7 | Low |
| Chan | ★★★★ | ★ | ★★ | 7 | Low |
| Cheng | ★★★★ | | ★★★ | 7 | Low |
| Cohn | ★★★ | ★★ | ★★★ | 8 | Low |
| Eisenhauer | ★★★★ | ★ | ★★★ | 8 | Low |
| Eltabbakh | ★★★★ | | ★★★ | 7 | Low |
| Gehrig | ★★★ | | ★★ | 5 | Moderate |
| Giugale | ★★★★ | ★ | ★★ | 7 | Low |
| Helm | ★★★★ | ★ | ★★ | 7 | Low |
| Hinshaw | ★★★★ | | ★★★ | 7 | Low |
| Leitao | ★★★ | | ★★ | 5 | Moderate |
| Mahdi | ★★★★ | ★ | ★★★ | 8 | Low |
| Mendivil | ★★★★ | | ★★★ | 7 | Low |
| Nevadunsky | ★★★ | | ★★ | 5 | Low |
| Obermair | ★★★★ | | ★★★ | 7 | Low |
| Pellegrino | ★★★★ | | ★★★ | 7 | Low |
| Perrone | ★★★★ | | ★ | 5 | Moderate |
| Ramzan | ★★★★ | ★ | ★★★ | 8 | Low |
| Scribner | ★★★★ | | ★★ | 6 | Moderate |
| Santi | ★★★ | ★ | ★★★ | 7 | Low |
| Subramanian | ★★★★ | | ★★★ | 7 | Low |
| Suidan | ★★★★ | ★ | ★★★ | 7 | Low |
| Tang | ★★★★ | | ★★★ | 7 | Low |
| Tinelli | ★★★★ | | ★★ | 6 | Moderate |
| Uccella | ★★★★ | ★ | ★★ | 7 | Low |

[a]Scoring: low, ≥7; moderate, 4–6; high, ≤3. Each *star* indicates one point in a given category, with a maximum of 4 stars available for selection, 2 stars available for comparability, and 3 stars available for outcome.

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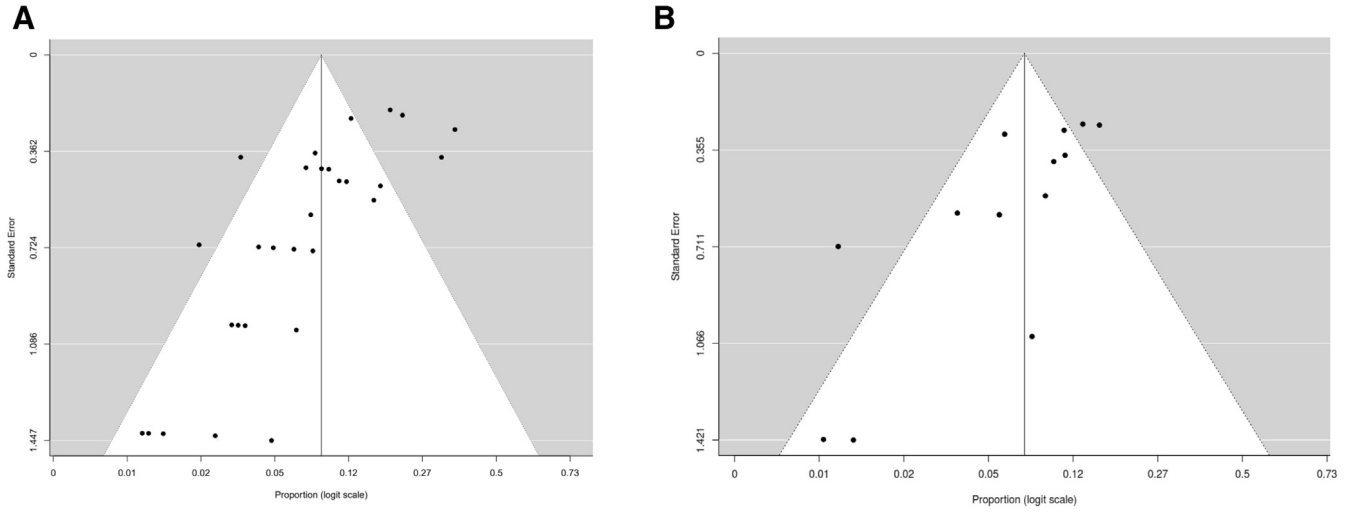
**APPENDIX 6**
## Funnel plot




Funnel plot of the proportion of conversions (*x-axis*) against standard error (*y-axis*) for **A,** laparoscopic hysterectomy, and **B,** robotic hysterectomy.
*Cusimano. Robotic and laparoscopic hysterectomy in endometrial cancer. Am J Obstet 2019.*