Minimally Invasive Lymphadenectomy in Uterine Cervical Cancer: A Systematic Review

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Abstract. *Background/Aim:* The aim of this study was to review the current literature on the role of minimally invasive lymphadenectomy in the treatment of cervical cancer. *Materials and Methods:* Non-randomized control trials published between January 2007 to May 2016 were identified by searching the Pubmed, EMBASE and Cochrane Library databases. Primary endpoints included operative outcomes (operative time, intraoperative blood loss, number of transfused patients and conversion rates), postoperative outcomes (length of postoperative hospital stay, postoperative morbidity and postoperative in-hospital mortality), and oncological outcomes (number of harvested lymph nodes, tumor recurrence, disease-free rates and overall survival rates). *Results:* A total of 17 studies with a total of 1,676 patients were included in the review. Compared to the open approach, minimally invasive lymphadenectomy demonstrated a significantly larger number of harvested lymph nodes, longer operative time, lower intraoperative blood loss and shorter postoperative hospital stay. No significant differences were observed between groups treated with an open, laparoscopic or robotic approach for the following criteria: lymph node metastasis, postoperative morbidity, tumor recurrence and postoperative mortality. *Conclusion:* Although a technically demanding and time-consuming procedure, minimally invasive lymphadenectomy appears to be safe and feasible and may offer an alternative approach in staging and treatment of cervical cancer. Multicentre randomized controlled trials investigating its long-term oncological outcomes and its cost-effectiveness are required to determine the advantages of this procedure over the open approach in cervical cancer.

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Key Words: Uterine cervical cancer, laparoscopy, robotics, lymphadenectomy.

Despite the great improvements in the diagnosis and treatment of cervical cancer, it is the fourth-most common cause both of cancer and of death from cancer in worldwide (1). In 2012, an estimated 528,000 cases of cervical cancer occurred, with 266,000 deaths (1). This is about 8% of the total cases and total deaths from cancer, with most cases occurring in developing countries (2).

Cervical cancer diagnosis is made by cervical biopsy or conization. It is important to estimate the extent of the disease not only for prognostic purposes, but also for treatment planning. Cervical cancer is staged by the International Federation of Gynecology and Obstetrics (FIGO) staging system, which is based on clinical examination, rather than surgical findings (1-3). The FIGO stage of disease is not changed by surgico-pathological findings of metastatic disease at the time of radical hysterectomy or lymphadenectomy, although lymph node metastasis is an important prognostic factor and may alter therapy (3-5).

Abdominal radical hysterectomy has been the primary treatment for early-stage invasive cervical cancer, with some modifications of the method through the years. It was first described by Wertheim of Vienna in 1898 (6), and since Meigs began to perform radical hysterectomy with pelvic lymphadenectomy in 1951 (7), there have been no major changes in surgical technique. Minimal invasive surgery has been regularly used by gynecologists for several decades. The objective of using a minimally invasive approach for the treatment of cervical cancer has been to reduce perioperative morbidity and to improve surgical and oncological outcomes. Since Nezhal *et al.* (8) and Canis *et al.* (9) suggested total laparoscopic radical hysterectomy with pelvic lymphadenectomy for the treatment of cervical cancer, several reports have shown its safety and feasibility (10-21). Reported advantages include less blood loss, shorter length of hospital stay, less postoperative pain and postoperative complications (8-10, 13, 14). Nevertheless, this procedure has not been widely adopted in surgical practice because of technical limitations such as a long learning curve, 2-

Table I. Characteristics of studies included in this review.

Author (Ref)	Study design	Country	Study period
Sert <i>et al.</i> (34)	Retrospective multicenter study	Oslo, Norway/Chapel Hill, NC and Orlando, FL, USA	2005-2011
Hoogendam <i>et al.</i> (35)	Observational cohort study	Utrecht, the Netherlands	2008-2013
Maggioni <i>et al.</i> (36)	Case-control study	Milan, Italy	2006-2009
Fastrez <i>et al.</i> (37)	Retrospective multicenter study	Brussels/ Liege/ Leuven, Belgium	2007-2011
Lambaudie <i>et al.</i> (38)	Retrospective case series	Marseille/Lille, France	2007-2010
Tinelli <i>et al.</i> (39)	Retrospective study	Avelinno, Italy	2003-2010
Nezhat <i>et al.</i> (40)	Prospective nonrandomized analysis	New York, USA	2000-2008
Lowe <i>et al.</i> (33)	Retrospective study	Chicago, USA	2003-2008
Cantrell <i>et al.</i> (41)	Retrospective analysis	North Carolina, USA	2005-2008
Segaert <i>et al.</i> (42)	Retrospective multicenter study	Belgium	2007-2014
Schreuder <i>et al.</i> (43)	Retrospective review	The Netherlands	2004-2008
Ramirez <i>et al.</i> (44)	Retrospective review	Texas, USA	2006-2008
Bogges <i>et al.</i> (24)	Case-control study	North Carolina, USA	2005-2007
Kim <i>et al.</i> (30)	Retrospective clinical review	Seoul, Korea	2006-2007
Estape <i>et al.</i> (45)	Case-matched analysis	USA	2002-2008
LeBlanc <i>et al.</i> (46)	Retrospective study	Lille, France	1997-2004
Diaz-Feijoo <i>et al.</i> (47)	Retrospective review	Barcelona, Spain	2009-2013

dimensional visualization with reduced depth perception, rigid instruments, ergonomic difficulty and tremor amplification (17, 18, 22). More recently, the development of the da Vinci system (da Vinci Surgical System; Intuitive Surgical Inc., Sunnyvale, CA, USA) in the mid 2000s provided a high-definition 3-D vision system, tremor filtration, seven degrees of motion ('wristed movement'), improved ergonomics and faster suturing. Furthermore, robotic-assisted surgical technique has been shown to require a shorter learning curve compared to conventional laparoscopy (23-26). However, robot-assisted surgery also has its limitations, such as the absence of touch sensation and increased costs.

In 2005, the da Vinci system was cleared by the US Food and Drug Administration for use in hysterectomy procedures (27), and in 2006, the first robot-assisted laparoscopic radical hysterectomy for cervical cancer was reported by Bilal M. Sert (28). Several larger case series followed, demonstrating feasibility and potential benefits of robot-assisted laparoscopic radical hysterectomy (29-33). As a result, the integration of robotic technology into laparoscopic surgery is being used with increasing frequency.

The aim of this study was to review current literature on both laparoscopic and robot-assisted lymphadenectomy in the treatment of cervical cancer.

Materials and Methods

Literature search. A PubMed, Embase and Cochrane Library database search was performed on literature published from 2007 to 2016. Only articles published in English and procedures performed by laparoscopic or robotic approach were included in this study. The following terms

were used to perform the research: "cervical cancer", "laparoscopy" or "laparoscopic", "robot" or "robotic" or "da Vinci", "minimally invasive", "radical hysterectomy", "pelvic lymphadenectomy" and "para-aortic lymphadenectomy".

Method of review. A total of 43 trials were identified. Eleven had overlapping data: in which case, only the study with the most recent information was included in the analysis. A total of 17 studies were included for analysis. The following parameters were extracted from each study to analyze: study features (first author, year of publication, study design), surgical and pathological parameters (age, body mass index, conversion rate). Data on operative time, estimated blood loss, number of retrieved lymph nodes, length of hospital stay, complications, positive lymph nodes, conversion to laparotomy, recurrence and morbidity were also extracted.

Inclusion criteria. For inclusion in the meta-analysis, a study had to fulfil the following criteria: (a) analyze the outcomes of robotic or laparoscopic lymphadenectomy for cervical cancer; (b) report on at least one of the outcome measures mentioned below; (c) if multiple studies were reported by the same institution, the most recent publication was included in the analyses.

Exclusion criteria. Articles were excluded if: (a) they were abstracts, letters or expert opinions; (b) they reported on minimally invasive lymphadenectomy for benign lesions or for other types of gynecological cancer; (c) there was overlap between authors or centers in the published literature.

Results

Study characteristics. In this study, 17 trials from the initial literature were included published between 2007 and 2016 with a total of 1,676 participants. A total of 837 patients underwent total robotic or robot-assisted surgery, 406

Table II.

Author (Ref)	Number of patients	Approach	Type of surgery
Sert <i>et al.</i> (34)	491	Total robotic (n=259)/ laparotomy (n=232)	Radical hysterectomy with pelvic lymphadenectomy
Hoogendam <i>et al.</i> (35)	100	Robot-assisted laparoscopic	Pelvic lymphadenectomy±radical hysterectomy or radical trachelectomy
Maggioni <i>et al.</i> (36)	80	Total robotic (n=40)/ laparotomy (n=40)	Radical hysterectomy with pelvic lymphadenectomy
Fastrez <i>et al.</i> (37)	37	Robot-assisted laparoscopic	Transperitoneal or retroperitoneal para-aortic lymphadenectomy
Lambaudie <i>et al.</i> (38)	58	Robot-assisted laparoscopy (n=22)/ total laparoscopic (n=16)/laparotomy (n=20)	Pelvic+para-aortic lymphadenectomy±simple colpohysterectomy or radical hysterectomy
Tinelli <i>et al.</i> (39)	99	Total laparoscopic (n=76)/total robotic (n=23)	Radical hysterectomy with pelvic lymphadenectomy±para-aortic lymphadenectomy
Nezhat <i>et al.</i> (40)	43	Total laparoscopic (n=30)/total robotic (n=13)	Radical hysterectomy with pelvic lymphadenectomy
Lowe <i>et al.</i> (33)	42	Robotic-assisted laparoscopy	Radical hysterectomy with pelvic lymphadenectomy
Cantrell <i>et al.</i> (41)	127	Total robotic (n=63)/laparotomy (n=64)	Radical hysterectomy with pelvic lymphadenectomy
Segaert <i>et al.</i> (42)	109	Robot-assisted laparoscopic	Radical hysterectomy with pelvic lymphadenectomy
Schreuder <i>et al.</i> (43)	28	Total robotic (n=14)/laparotomy (n=14)	Radical hysterectomy with pelvic lymphadenectomy
Ramirez <i>et al.</i> (44)	5	Total robotic	Radical parametrectomy & bilateral pelvic lymphadenectomy
Bogges <i>et al.</i> (24)	100	Robotic-assisted (n=51)/laparotomy (n=49)	Radical hysterectomy with pelvic lymphadenectomy
Kim <i>et al.</i> (30)	10	Total robotic	Radical hysterectomy with pelvic lymphadenectomy
Estape <i>et al.</i> (45)	63	Laparotomy (n=14)/total laparoscopic (n=17)/ robotic-assisted (n=32)	Radical hysterectomy with pelvic lymphadenectomy± para-aortic lymphadenectomy
LeBlanc <i>et al.</i> (46)	184	Total laparoscopic	Extraperitoneal bilateral infrarenal paraortic lymph node dissection
Diaz-Feijoo <i>et al.</i> (47)	100	Robotic-assisted laparoscopy (n=17)/ total laparoscopic (n=83)	Extraperitoneal para-aortic lymphadenectomy

underwent total laparoscopy and 433 laparotomy. Six of the studies were conducted in the USA, one both in USA and Norway, two in the Netherlands, two in Italy, two in Belgium, one in Korea, one in Spain and two in France. When pelvic or para-aortic lymphadenectomy was performed as the only surgical procedure, it is referred to as “isolated”, and when it was associated with hysterectomy, it is described to as “combined”. Usually, pelvic with/without para-aortic lymphadenectomy follows radical hysterectomy. Thus, most studies present the results of both procedures (Tables I and II).

Clinicopathological characteristics. The general characteristics of surgical groups are shown in Table III. The mean age of patients at surgery was 41.5 years for robotic approach group, 46.2 years for the laparoscopic group and 50.1 years for laparotomy group. The body mass index (BMI) status was reported in all studies and did not differ significantly between the surgical groups.

Lymphadenectomy outcomes. All studies report the number of resected lymph nodes. One study reported a significantly larger number of removed lymph nodes in the laparotomy group (36) and four did so for the robotic group (24, 41, 45,

47). Lymph-node metastasis was documented in 12 trials and lymphatic complications in 13, but none of them found any significant difference between the three groups (Table IV).

Operative outcomes. The mean operative time was provided by all studies. It ranged between 144 and 434 min for the robotic approach, between 132 and 318 min for laparoscopic, and between 114 and 247.8 min for laparotomic. Two of the studies showed a significantly longer operative time in the laparotomic group (24, 41), one in the laparoscopic group 38 and four (4) in the robotic group (5, 36, 39, 43). The estimated blood loss (EBL) was reported in 16 studies, seven of which have found a significantly lower blood loss in the robotic group. The mean EBL ranged from 20 to 355 ml in the robotic group, from 90 to 209.4 ml in the laparoscopic group and from 221.8 to 2,000 ml in the laparotomic group. The transfusion rate was recorded in 15 studies and was significantly lower in the robotic group in two studies (28, 45). The conversion rate was documented in 15 studies and ranged from 0% to 5.3% (Table V).

Postoperative outcomes. The postoperative morbidity rates were reported in 15 trials. None of them demonstrated any

Table III. Clinicopathological characteristics (robotic/laparoscopic/laparotomy approach).

Author (Ref)	Age, years	BMI, kg/m ²	FIGO stage ≤IB1: ≥IB2	Follow-up, months
Sert <i>et al.</i> (34)	44.5±11.7/---/46.7±12.2*	27.6±6.5/---/27.4±6.6 ^{NS}	242:17/---/205:24	34.6±21.7/---/45.2±28.5**
Hoogendam <i>et al.</i> (35)	41 (23-81)/---/---	23.2 (18.3-35.1)/---/---	90:10/---/---	29.5 (2.5±67.1)/---/---
Maggioni <i>et al.</i> (36)	44.1±9.1/---/49.8±14.1*	24.1±5.5/---/23.6±5 ^{NS}	30:10/---/26:14	NR
Fastrez <i>et al.</i> (37)	58 (38-78)/---/---	24.3 (17.3-31.3)/---/---	0:8/---/---	NR
Lambaudie <i>et al.</i> (38)	50.5 (3664)/45 (3257)/ 53 (3172)*	22 (17.8-38.6)/21.9 (14.3-39.4)/ 21.9 (17.234) ^{NS}	2:20/1:15/0:20	11.55 (3.5-22.5)/19.45 (2.4-50)/34.6 (15.8-84.4)***
Tinelli <i>et al.</i> (39)	43.1±8.9/41.9±7.1/--- ^{NS}	28±4/29±3/ ^{NS}	21:2/69:7/--- ^{NS}	24.5 (2-48)/46.5 (3-90)/---
Nezhat <i>et al.</i> (40)	54.8 (39-78)/46.8 (29-63)/--- NR	NR	11:2/26:4/--- NR	12/29/--- NR
Lowe <i>et al.</i> (33)	41/---/---	25.1/---/---	36:6/---/---	NR
Cantrell <i>et al.</i> (41)	43 (17-75)/---/41.5 (20-72) ^{NS}	28 (-)/---/25 (19-37) ^{NS}	58:5/---/56:8 ^{NS}	12.2 (0.2-36.3)/---/28 NR
Segaert <i>et al.</i> (42)	---/40.8 (28.4-63.4)/ 42.5 (27.3-68.3) ^{NS}	---/28.1 (18.4-40.8)/28.2 (17.4-46.4) ^{NS}	---/35:0/53:1 ^{NS}	---/7.2/15.2 NR
Schreuder <i>et al.</i> (43)	43 (31-78)/---/46 (32-68) NR	NR	11:1/---/13:1 NR	26 (17-32)/---/42 (31-54) NR
Ramirez <i>et al.</i> (44)	42 (38-52)/---/---	23.8 (17.7-26.5)/---/---	5:0/---/---	7.5 (1.31-3.8)/---/---
Bogges <i>et al.</i> (24)	47.4±12.9/---/41.9±11.2*	28.6±7.2/---/26.1±5.1 ^{NS}	43:8/---/44:5 ^{NS}	NR
Kim <i>et al.</i> (30)	49.9 (34-75)/---/---	26.34 (20.3-31.6)/---/---	10:0/---/---	9/---/---
Estape <i>et al.</i> (45)	55 (3383)/52.8 (37-83)/ 42 (27-71) ^{NS}	29.7 (24.8-36.3)/28.1 (20.8-36.8)/29.5 (20.1-44.3) ^{NS}	29:3/16:1/13:1 ^{NS}	284.2±152.1/941.6±273.9/ 1382.4±592.7 (days)***
LeBlanc <i>et al.</i> (46)	---/45 (25-75)/---	---/27.1 (16.841)/---	---/0:179 (5 recurrent)/---	---/32.9 (3-89)/---
Diaz-Feijoo <i>et al.</i> (47)	49 (29-66)/51 (24-74)/--- ^{NS}	23 (16-32)/26.5 (18-44)/ ---*	0:17/0:83/--- NR	13.4 (1-40.5)/NR/--- NR

Data are the mean±SD or median (range). ^{NS}: Non-significant, NR: not reported. Significant at **p*≤0.05, ***p*≤0.01, ****p*≤0.001, *****p*≤0.0001

Table IV. Lymphadenectomy outcomes (robotic/laparoscopic/laparotomic approach).

Author (Ref)	Positive LVSI	No of lymph nodes removed	No of positive nodes	Lymphatic complications
Sert <i>et al.</i> (34)	9 Patients/---/---	9 (11.8%)/---/---	25 (12%)/---/29 (10%) ^{NS}	9/---/12
Hoogendam <i>et al.</i> (35)	46/---/---	24 (10-56)/---/---	10/---/---	9/---/---
Maggioni <i>et al.</i> (36)	NR	20.4 ± 6.9/---/26.2±11.7*	NR	1/---/6 ^{NS}
Fastrez <i>et al.</i> (37)	NR	27.5 (1-54)/---/---	5 Patients (13.5%)/---/---	NR
Lambaudie <i>et al.</i> (38)	NR	9/7.5/12 ^{NS}	2/2/2 ^{NS}	4/1/0 ^{NS}
Tinelli <i>et al.</i> (39)	NR	Pelvic: 24.7±5.2/27.1±4.7/--- ^{NS} Aortic: 10.2±2.8/11.5±1.8/--- ^{NS}	2 patients/9 patients/---	2 (8.6%)/9 (11.8%)/---
Nezhat <i>et al.</i> (40)	9/16/---	24.7 (11-51)/31 (10-61)/--- ^{NS}	1/3/---	1/0/---
Lowe <i>et al.</i> (33)	NR	25 (12-60)/---/---	12% Of all patients/---/---	0/---/---
Cantrell (41)	NR	29 (13-99)/---/24 (4-72)*	5 (8%)/---/9 (14%)	NR
Segaert <i>et al.</i> (42)	30/---/---	23 (6-70)/---/---	NR	0/---/---
Schreuder <i>et al.</i> (43)	NR	29 (19-76)/---/26 (10-41) ^{NS}	NR	NR
Ramirez <i>et al.</i> (44)	4 (80%)/---/---	14 (6-16)/---/---	0/---/---	1/---/---
Bogges <i>et al.</i> (24)	NR	33.8±14.2/---/23.3±12.7***	NR	1/---/1
Kim <i>et al.</i> (30)	NR	27.6 (12-52)/---/---	0/---/---	0/---/---
Estape <i>et al.</i> (45)	NR	32.4±10/ 18.6±5.3/ 25.7±11.5	NR	NR
LeBlanc <i>et al.</i> (46)	NR	---/20.8 (1-52)/---	---/44 Patients (24.3%)/---	---/20 Patients (10/9%)/---
Diaz-Feijoo <i>et al.</i> (47)	NR	17 (10-31)/14 (4-62)/---*	1 Patient (5.9%)/NR/--- NR	3 (17.6%)/NR/--- NR

Data are the mean±SD or median (range). LVSI: lymphovascular space invasion; ^{NS}: non-significant, NR: not reported. Significant at **p*≤0.05, ****p*≤0.001.

significant difference in favor of the robotic group. The overall mortality rates were reported in 12 studies and ranged from 0% to 40% in the robotic group, from 0% to 11.8% in the laparoscopic group and from 0% to 20% in the

laparotomic group but none of the comparative studies found significant differences between them. The mean length of postoperative hospital stay was 2.78 days in the robotic group, 3 days in the laparoscopic group and 5 days in the

Table V. Operative outcomes (robotic/laparoscopic/laparotomic approach).

Author (Ref)	Operative time (min)	Estimated blood loss (ml)	Transfusion rate	Conversion rate
Sert <i>et al.</i> (34)	220±53/---/ 156±57***	<150 ml: 206±80/---/ 10±4≥150 ml: 53±20/---/222±96***	Significantly lower in the RRH group	NR
Hoogendam <i>et al.</i> (35)	319 (175–472)/---/---	185/---/---	0/---/---	1 (Laparoscopy)/ ---/---
Maggioni <i>et al.</i> (36)	272.27±42.3/---/199.6±65.6***	78±94.8/---/221.8±132.4***	3/---/9NS	0/---/---
Fastrez <i>et al.</i> (37)	200 (60–340)/---/---	Median hemoglobin fall 1.36 g/dl (0–2.7)	1/---/---	1/---/---
Lambaudie <i>et al.</i> (38)	210 (120–330)/267.5 (165–420)/210 (135–330)**	NR	1/0/1NS	0/0/-
Tinelli <i>et al.</i> (39)	323±30/255±25/---*	157±7/95±5/---NS	0/0/---	0/0/---
Nezhat <i>et al.</i> (40)	323 (232–453)/318 (200–464)/---NS	157 (50–400)/200 (100–500)/---NS	0/0/---	0/0/---
Lowe <i>et al.</i> (33)	215 (120606)/---/---	50 (25–150)/---/---	0/---/---	1/---/---
Cantrell <i>et al.</i> (41)	213 (75–290)/---/240 (181–420)***	50 (20–400)/---/400 (100–1200)****	NR	NR
Segaert <i>et al.</i> (42)	281 (160–550)/---/---	150 (15–1500)/---/---	11/---/---	0/---/---
Schreuder <i>et al.</i> (43)	434 (264–610)/---/225 (170–330)***	300 (50–1000)/---/2000 (1000–4.600)***	NR	0/---/---
Ramirez <i>et al.</i> (44)	365 (331–430)/---/---	100 (50–175)/---/---	0/---/---	0/---/---
Bogges <i>et al.</i> (24)	210.9±45.5/---/247.8±48.8***	96.5±85.8/---/416.8±188.1****	0/---/4NS	0/---/---
Kim <i>et al.</i> (30)	207 (120–240)/---/---	355/---/---	0/---/---	0/---/---
Estape <i>et al.</i> (45)	2.4h±0.8h/2.2h±0.7h/1.9h±0.6hNS	130±119.4/209.4±169.9/621.4±294.0	1/0/5	0/0/---
LeBlanc <i>et al.</i> (46)	---/155 (90–280)/---	---/100 (25–500)/---	---/0/---	---/0/---
Diaz-Feijoo <i>et al.</i> (47)	150 (85–270)/150 (80–255)/---NS	20 (5–350)/90 (10–260)/---*	0/NR/---	0/NR/---

RRH: Robotic radical hysterectomy; NS: non-significant, NR: not reported. Significant at * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, **** $p \leq 0.0001$.

laparotomy group. Six studies reported a significantly shorter postoperative hospital stay for the robotic group (24, 36, 38, 41, 43, 51). The recurrence rate was given in 15 studies but none of them reported any significant difference between groups (Table VI).

Discussion

Radical hysterectomy with pelvic lymphadenectomy has been the primary treatment for cervical cancer since the mid 20th century. Minimally invasive surgery *via* laparoscopy has been pursued by gynecologists since the 1990s. A number of studies have demonstrated its advantages over laparotomy, which include reduced blood loss, shorter recovery time, shorter hospitalization and improved quality of life (48, 49). Nevertheless, the laparoscopic approach has not received widespread adoption due to disadvantages such as 2-dimensional visualization, limited range of motion, reduced depth perception and a long learning curve (50).

More recently, robotic technology has facilitated the application of minimally invasive surgery. Its use in oncological procedures has increased since the first robotic radical hysterectomy with lymphadenectomy was carried out in 2006 (51), owing to advances in laparoscopic instruments (8, 9, 19, 52). The da Vinci Surgical System provides stable 3-dimensional vision, tremor filtration, a wider range of motion with wristed instruments and a more ergonomic surgeon position (23, 30, 53–55).

Several studies have shown the feasibility and the safety of minimally invasive surgery in the treatment of cervical cancer, concerning both laparoscopic and robotic approaches (18, 19, 56). However, some results are conflicting (10, 19–21). Therefore, we reviewed the current literature with the aim of summarizing the role of minimally invasive radical hysterectomy and lymphadenectomy in uterine cervical cancer. Our study includes 17 non-randomized controlled trials which describe the results of either robotic or laparoscopic surgery in cervical cancer. No significant difference in characteristics such as age and BMI was found between robotic and laparoscopic groups, nor in comparison with the laparotomy group.

The results concerning the operative time are controversial. Some studies showed that it was significantly longer in robotic lymphadenectomy (34, 36, 39, 43), others found it was longer in abdominal lymphadenectomy (24, 41), and one (38) in laparoscopic lymphadenectomy. This was associated with the learning curves, the experience of the surgeons and the time for setup, that most studies did not state whether this was included or not in the documented operative time. Bogess *et al.* performed a sub-analysis on the operative time of robot-assisted laparoscopic radical hysterectomy with lymphadenectomy in patients with cervical cancer which revealed a decrease of 50 min between the first (243 min) and the last 12 patients (193 min) operated on (24). The EBL was found to be lower in the robotic group in all comparative studies. The reasons for reduced blood loss include stable

Table VI. Postoperative outcomes (robotic/laparoscopic/laparotomy approach).

Author (Ref)	Overall morbidity	Mortality	Length of hospital stay (days)	Recurrence rate
Sert <i>et al.</i> (34)	75 (3%)/---/61 (4%)	7/---/9 ^{NS}	≤3:156/---/35 >3:103/---/197 ^{***}	23 (9%)/---/21 (9%) ^{NS}
Hoogendam <i>et al.</i> (35)	NR	7/---/---	4 (2-8)/---/---	13 (13%)/---/---
Maggioni <i>et al.</i> (36)	45/---/24	1/---/0	3.7±1.2/---/5±2.4 ^{**}	5/---/5
Fastrez <i>et al.</i> (37)	5 (13.5%)/---/---	15 (40%)/---/---	6 (2-10)/---/---	17 (46%)/---/---
Lambaudie <i>et al.</i> (38)	5 (22.7%)/2 (12.5%)/ 4 (20%) ^{NS}	2 (9.1%)/2 (11.8%)/ 4 (20%) ^{NS}	3 (3-10)/4.5 (3-8)/ 7 (3-17) ^{**}	6 (27.3%)/4 (25%)/ 6 (30%) ^{NS}
Tinelli <i>et al.</i> (39)	NR	NR	3± (1.2---7)/4± (2.3-7)/--- ^{NS}	1 (4.4%)/4 (5.4%)/--- ^{NS}
Nezhat <i>et al.</i> (40)	4/6/--- ^{NS}	NR	2.7 (1-6)/3.8 (2-11)/--- ^{NS}	0/0/--- ^{NS}
Lowe <i>et al.</i> (33)	5 (12%)/---/---	NR	1/---/---	NR
Cantrell <i>et al.</i> (41)	2/---/3	1/---/2 ^{NS}	1 (1-3)/---/4 (3-8) ^{****}	1/---/7 ^{NS}
Segaert <i>et al.</i> (42)	24 (22%)/---/---	6 (5.5%)/---/---	4.5 (3-19)/---/---	18 (16.5%)/---/---
Schreuder <i>et al.</i> (43)	1/---/3	NR	4 (2---14)/---/9 (7---16) ^{***}	2/---/1
Ramirez <i>et al.</i> (44)	2/---/---	0/---/---	1 (1-2)/---/---	0/---/---
Boggess <i>et al.</i> (24)	4 (7.8%)/---/8 (16.3%) ^{NS}	NR	1/---/3.2 ^{****}	NR
Kim <i>et al.</i> (30)	1/---/---	0/---/---	7.9 (5-17)/---/---	0/---/---
Estape <i>et al.</i> (45)	6 (18.8%)/4 (23.5%)/ 4 (28.6%) ^{NS}	0/0/2 (14.3%) ^{NS}	2.6±2.1/2.3±1.4/4.0±1.7 ^{NS}	1 (3.2%)/0/2 (14.3%) ^{NS}
LeBlanc <i>et al.</i> (46)	---/1 Patient/---	---/0/---	---/1.4/---	---/67 Patients (36.4%)/---
Diaz-Feijoo <i>et al.</i> (47)	3 (17.6%)/7 (8/4%)/--- ^{NS}	5 (29.4%)/NR/--- NR	2/2/--- ^{NS}	1 (5.9%)/NR/--- NR

^{NS}: Non-significant, NR: not reported. Significant at ^{**} $p \leq 0.01$, ^{***} $p \leq 0.001$, ^{****} $p \leq 0.0001$.

traction of robotic arms, an excellent 3D view and precise dissection with the robotic instruments.

The number of retrieved lymph nodes is a prognostic factor of oncological adequacy and long-term outcome of the procedure. Four studies indicated a significantly larger number of removed lymph nodes in the robotic group compared to laparotomy and one did so compared to the laparoscopic approach. Nevertheless, none of these studies revealed a significant difference regarding the number of positive lymph nodes or the percentage of lymphatic complications between the three groups. The length of hospital stay is an important outcome variable, affecting patient satisfaction and cost analysis. In this review, it became clear that the duration of hospital stay was significantly shorter with robotic and laparoscopic treatment compared to laparotomy.

Analyzing morbidity after radical hysterectomy with pelvic lymphadenectomy, no major difference was found in the literature between open and minimally invasive approaches. The postoperative morbidity rate is usually used to assess the safety of such procedures. It ranged between 3 and 22.7% in the 1-h robotic group, which suggests that a robotic approach might be considered as safe as an open laparatomic one. The recurrence and mortality rates are used to assess the feasibility of the procedure. Both were found to be similar in the three groups, which demonstrates the efficacy of a minimally

invasive approach in the treatment of cervical cancer in comparison with a laparatomic approach.

The present study has several limitations. Firstly, it was not a meta-analysis in order to come to more accurate conclusions. Secondly, all the included trials were observational and their results cannot be generalized to the extent that those of randomized controlled trials can. Thirdly, there was heterogeneity between the three groups because it was impossible to match patient characteristics in all studies. Finally, between individual studies, the follow-up time varied significantly.

Conclusion

In conclusion, although robot-assisted lymphadenectomy in cervical cancer is a technically demanding and time-consuming procedure, the results of this study suggest it may be an acceptable alternative to a total laparoscopic or laparatomic approach, regarding surgical and short-term oncological outcomes. Randomized controlled trials, including surgeons' ergonomics and costs, may give more definite results on the comparability of these three surgical techniques.

Conflicts of Interest

All Authors declare that they have no competing interests in regard to this study.

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Received October 24, 2016

Revised November 14, 2016

Accepted November 15, 2016