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Review Article

Beyond the scalpel: unveiling the transformative landscape of robotic gynecologic procedures

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ABSTRACT

This review aims to present a comprehensive assessment of the current status and impact of robotic-assisted laparoscopy (RAL) in gynecological surgery across various subspecialties, exploring its benefits, applications, and challenges. This included studies evaluating RAL in general gynecology, urogynecology, and gynecological oncology. RAL has emerged as a transformative technology, demonstrating efficacy in procedures ranging from routine gynecologic tasks to complex oncological surgeries. The adoption of RAL has facilitated improved surgical outcomes, reduced learning curves, and enhanced visualization. Superior dexterity, 3D vision, and filtered tremor contribute to its precision. The ergonomic advantages, including intuitive instrument movements and a third assisting arm, further enhance positive outcomes. Notably, RAL has shown promise in managing challenging patient demographics, such as morbidly obese individuals and those with intricate pelvic anatomy. In gynecological oncology, RAL has become integral, manifesting benefits in endometrial, cervical, and ovarian cancer surgeries. Despite challenges like cost considerations, RAL continues to shape the landscape of gynecological surgery, promising improved patient outcomes and contributing to the paradigm shift toward minimally invasive approaches. Ongoing research should focus on long-term cost-effectiveness, patient perspectives, and attitudes toward RAL, ensuring its continued integration into the evolving field of gynecological surgery.

Keywords: Gynecologic cancer, Minimally invasive surgery, Robotic surgery, Gynecologic oncology

INTRODUCTION

Over the past three decades, minimally invasive surgery (MIS) has significantly transformed the management of gynecologic disorders. The emergence of robotic surgery, in particular, has marked a pivotal advancement in this field. While traditional laparoscopy initially provided less invasive options for procedures such as hysterectomies, tubal ligations, adnexal surgery, lymphadenectomies, and radical hysterectomies, its steep and prolonged learning curve has deterred some surgeons. Additionally, not all patients and procedures are suitable for traditional laparoscopy, resulting in the continued prevalence of abdominal incisions for the majority of advanced gynecologic surgeries.[1]

While laparoscopic hysterectomies exhibit lower complication rates compared to vaginal or abdominal approaches, the advantages of laparoscopic surgery extend beyond reduced complications. Recognized benefits include shorter hospital stays, quicker recoveries, diminished blood loss, enhanced cosmesis, and fewer overall complications.[2]

Despite these advantages, traditional laparoscopy faces several limitations. Its protracted learning curve, counterintuitive hand movements, and the use of long instruments through fixed entry points amplify small movements and tremors, challenging fine motor control. Limited instrument motion range often necessitates ergonomically demanding positions, contributing to surgeon fatigue and frustration during lengthy cases. Additionally, 2-dimensional optics and an unstable camera platform may compromise depth perception and visualization, contingent on the stability and skill of the assistant operating the camera.

In light of these constraints, numerous intricate surgical procedures continue to be conducted as open procedures. However, the introduction of the da Vinci robotic system (DRS), developed by Intuitive Surgical, Sunnyvale, CA, USA, and FDA-approved for gynecologic surgery in April 2005, has ushered in a transformative era. This advanced robotic system has enabled the shift from traditional abdominal incisions to minimally invasive techniques, offering a more sophisticated and precise approach to surgeries that were previously reliant on open procedures.

The term "robot" originates from the Czech word "robota," introduced by playwright Karel Capek in 1921. In recent years, the medical field has embraced robotic technology. The evolution began with HERMES, a voice-recognition system controlling medical devices. In 1994, the FDA approved AESOP, a single robotic arm for camera control. ZEUS, with two arms, pioneered telesurgery in 1999. Telesurgery's debut occurred in 2001, connecting a surgeon in New York to a patient in Strasbourg, France, for a laparoscopic cholecystectomy.[3] Initially funded by various entities, including the Stanford Research Institute and the U.S. Defense Department, these platforms aimed at battlefield telesurgery faced limitations. Intuitive Surgical Inc. advanced this technology, leading to the development of the DRS. The acquisition of ZEUS followed, and the first successful DRS surgery took place in Belgium in 1997.[4]

The da Vinci robotic platform comprises three key elements: the surgeon's console, directing robotic arm movements; the vision system; and the patient-side cart, now equipped with four arms. After port site placement and cart docking, the surgeon, seated at the console, gains a three-dimensional, high-definition view of the pelvis. The stabilized camera system, controlled by foot pedals and arm movements, allows precise visualization. Operating the robotic arms and Endo Wrist instruments at the console involves natural hand and wrist motions, mimicking open surgery. These instruments boast seven degrees of freedom, one more than the human hand. The system minimizes tremors, providing ergonomic support with armrests and adjustable height and eye pieces. Foot pedals facilitate ease of use, controlling arm swapping, camera movement, and currents for Endo Wrist instruments. This comprehensive design alleviates fatigue, frustration, and strain, particularly during prolonged or challenging laparoscopic procedures. The robotic platform enables less experienced laparoscopic surgeons to tackle complex procedures with ease. Quick progression along the learning curve allows for tasks like intracorporeal suturing, knot tying, ureterolysis, lymphadenectomies, and adhesion lysis with improved visualization. The 10–15mm assistant port provides additional support for suctioning, retraction, vessel coaptation, and the passage of surgical items. Uterine manipulation and access through the vaginal canal post-hysterectomy offer unique advantages in gynecologic surgery.

The widespread adoption of robotic technology in gynecology has empowered surgeons to undertake procedures they may have hesitated to perform with traditional laparoscopy (Table 1). This shift is observed not only in general gynecology but also across various subspecialties. In general and reproductive gynecology, robots are increasingly employed for hysterectomies, myomectomies, adnexal surgery, and tubal anastomosis. In urogynecology, sacrocolpopexies and fistula repairs benefit from robotic assistance. The most notable impact is seen in gynecologic oncology, where robots play a growing role in performing hysterectomies, lymphadenectomies for endometrial cancer staging, radical hysterectomies and trachelectomies for cervical cancer, and staging and debulking of early ovarian cancer. This advancement expands the availability of minimally invasive surgery options for patients.

Table 1: Advantages and disadvantages of robotic surgery.

Advantages	Disadvantages
Better ergonomics	High maintenance cost
3D optics	Absence of tactile feedback
7 degree of freedom	Additional learning curve
Fast learning curve	Additional docking time
Integrated firefly system	
Intuitive handling of instruments	
Less post-operative pain	

Conventional laparoscopy (CL) in gynecological surgery has offered benefits like shorter hospital stays and faster recovery. However, its limited application in complex pelvic procedures due to space constraints and intricate anatomy led to the introduction of robotic-assisted laparoscopy (RAL).[5,6] RAL addresses CL limitations with superior dexterity, intuitive movement, 3D vision, improved ergonomics, and a shorter learning curve. Unlike CL, RAL filters tremors for precise operations, provides stable 3D views, and replicates surgeon hand movements. This contrasts with CL, where hand and instrument actions are counterintuitive. The use of a third arm in RAL enhances surgeon control, offering ergonomic advantages, particularly noted in models representing various body weights.[7,8]

A Cochrane review, based on 12 randomized controlled trials (RCTs), found comparable surgical complication rates between RAL and CL in benign gynecological disease. Limited survival data makes the evidence uncertain for malignant gynecological disease.[9] Retrospective studies, however, suggest that RAL improves surgical performance without increasing time, blood loss, or complications, while reducing laparotomy conversion rates. Challenges in early robotic surgery adoption, including cost and learning curve, were not addressed in the review, and it used outdated robotic systems.[10] Recent studies show RAL's contribution to widespread minimal invasive surgery adoption and reduced perioperative mortality in uterine cancer cases. Future cost-effectiveness studies are crucial for high-volume robotic centers using modern platforms.[11]

ERGONOMICS IN ROBOTIC SURGERY

The transition from open surgery to MIS has greatly improved perioperative outcomes for patients, yet the impact on surgeons' well-being has received minimal attention. Surgeons engaging in MIS, compared to open surgery, experience higher rates of work-related musculoskeletal symptoms (WMS), contributing to reduced productivity and potential career longevity. While robotic platforms aim to enhance surgeon ergonomics, studies reveal that self-reported physical workload and muscle activity are lower with RAL than with CL.[12-17] However, challenges persist as objective analysis using electromyography (EMG) indicates varying muscle fatigue patterns, particularly in the forearm with CL and the shoulder/neck with RAL. Examining ergonomic stress during exercises in simulated obese models, researchers found increased muscle activity and movement requirements, with no significant differences observed based on patient BMI. Bariatric surgeons report higher pain levels with open/CL procedures compared to RAL surgery, suggesting the potential benefits of RAL in reducing WMS when operating on obese patients.[18,19] Nonetheless, further investigation during live surgeries is essential to validate these findings.

Robotic surgery in benign and reproductive gynecologic surgery

Robotic surgery has been incorporated widely into benign gynecological procedures which are shown in Table 2.

Table 2: Role of robotic surgery in benign gynaecological procedures.

Role of robotic surgery	Benign gynaecological procedures
Tubal anastomosis	Previous history of tubal ligation
Endometriosis	Hysterectomy, adhesiolysis
Uterine fibroid	Myomectomy, hysterectomy
Abnormal uterine bleeding	Hysterectomy

Tubal anastomosis

The da Vinci robot was initially reported in urologic procedures in 1995 and cardiac procedures in 2001. In gynecology, the first robotic surgery case was a tubal anastomosis (TA) in 2000.[20,21] While two studies compare robotics to other approaches in performing TA, both are excluded due to small sample sizes (n<20).[22,23] The first study by Goldberg and Falcone at the Cleveland Clinic, involving 10 robotic cases and 15 laparoscopic cases, reported higher tubal patency and pregnancy rates in the robotic group. However, biases are present, with noncomparable groups and loss to follow-up in the laparoscopic group. The robotic group also had longer operating room times and higher estimated blood loss compared to laparoscopic TA. In the second study, 18 patients underwent DRS for TA, compared to 10 historic controls (HC) who underwent open surgery (OS) for TA a year earlier. The same surgeon performed all cases, and infertility factors were excluded in both groups. DRS had longer operative times (201 min vs. 155 min) but console time was comparable to OS. Patients in the DRS group were discharged within 4 hours, while OS patients had an average postoperative hospital stay of 35 hours. One complication occurred in the DRS group, a trocar injury to the inferior epigastric artery, promptly addressed intraoperatively with no conversions to OS. DRS patients had less analgesia use and faster return to activities of daily living (11 vs. 28 days). Clinical outcomes were similar, although the DRS group had a shorter follow-up. DRS TA was deemed cost-effective, balancing increased costs with quicker recovery and shorter hospital stays in the OS group.[23]

Adnexal surgery and endometriosis treatment

The literature on adnexal surgery often lacks detailed characterization, with many reported procedures conducted alongside hysterectomies. Traditional laparoscopy is typically suitable for isolated oophorectomies or cystectomies, initially described in 1979.[24] However, when dealing with adhesive disease, advanced endometriosis, or large-complex masses, robotics may facilitate the completion of desired procedures without resorting to open surgery. Nezhat et al. reported in 1999 that hysterectomies with bilateral salpingo-oophorectomies (BSO) took an additional 99 minutes compared to those without BSO.[25] Another series by the same group showcased successful robot-assisted treatment of endometriosis, involving resection of lesions, adhesion lysis, ovarian cystectomy, and ovary repair, without conversions or complications.[26] Similarly, Liu et al reported a successful partial bladder resection due to infiltrating endometriosis using DRS.[27] Chammas et al also described a DRS-managed endometriosis case involving surgical resection of a bladder mass, rectal nodule, ovarian cysts, and peritoneal endometriotic implants.[28] Hence, DRS is advantageous for adnexectomy, particularly in obese women, where a challenging dissection is expected.

A systematic review and meta-analysis[29] have indicated that surgical excision, particularly with a focus on deep infiltrating endometriosis (DIE), holds advantages over ablation for pain relief. RAL is identified as an enabling tool for excisions in DIE, potentially making surgeries safer and more accessible, particularly in the context of nerve-sparing techniques and pelvic nervous system pathology.[30]

The utilization of 3D vision in RAL may enhance the identification of endometriosis lesions compared to 2D laparoscopy (100% vs. 77.9%). The only randomized trial (LAROSE) included women with suspected endometriosis at any stage, but it was underpowered for complications and blood loss outcomes.[31] For DIE, retrospective and prospective databases and case series have reported major complication rates of 6%-7% in CL, whereas the largest multicenter RAL case series reported a 3% major complication rate.[32,33] In summary, current data suggest that RAL is at least as effective as CL, with non-randomized data hinting at potential lower complication rates. Further randomized control trials are needed to evaluate RAL's benefits for endometriosis surgery across different stages and procedures.

Myomectomy

Myomectomy remains the gold standard for treating symptomatic myomas in women desiring future fertility. Despite the introduction of laparoscopic myomectomies, the majority are still performed via open surgery due to technical challenges. Laparoscopic myomectomies are underutilized, attributed to complex suturing, precise dissection, and the risk of uterine rupture. Robotic surgery provides a minimally invasive alternative, facilitating suturing, knot tying, and enhanced visualization. Observational studies and case reports highlight the feasibility and success of robotic myomectomies, with comparative studies showing less blood loss, shorter hospital stays, and fewer complications compared to open surgery.[34-37]

The collective findings from these studies suggest that robotic-assisted laparoscopic DRS myomectomy is comparable to laparoscopic (LSC) myomectomy, particularly in the hands of experienced LSC surgeons. DRS may demonstrate superiority over LSC in cases involving large or multiple myomas, expanding the pool of candidates for MIS. For less experienced laparoscopic surgeons or patients facing anticipated challenges with myomectomy, DRS may present a preferable option over LSC. Conversely, DRS appears to outperform OS, though the absence of long-term outcome studies warrants caution. The theoretical risk of increased uterine rupture with DRS compared to OS underscores the need for comprehensive long-term data before advocating routine DRS myomectomies over OS.

Hysterectomy

RAL hysterectomy demonstrated low morbidity and shorter hospital stays in complex cases involving factors like previous surgery, endometriosis, uterine weight exceeding 250g, and BMI above 30kg/m^2. While a Cochrane review including 12 studies suggested comparable complication rates between RAL and CL hysterectomy, it did not specifically consider case complexity.[9] Hysterectomy in women with obesity, a recognized complex scenario, is associated with increased complications, and laparoscopic approaches are considered advantageous over abdominal hysterectomy, especially in cases of severe obesity (BMI 40kg/m^2 or over). A retrospective study involving 545 women revealed similar perioperative outcomes, including age, BMI, blood loss, and operative time, in benign hysterectomy cases performed through CL and RAL.[38] However, the CL group exhibited a higher conversion rate to laparotomy (CL 6.2% vs. RAL 1.7%, $p<0.007$) and increased incidence of vaginal vault dehiscence (CL 6.2% vs. RAL 1.7%). Notably, the RAL group presented with more advanced endometriosis, adhesions, and larger uterine weight. A retrospective review of 1535 obese patients demonstrated a significant increase (28-fold) in conversion to laparotomy hysterectomy with CL and a 17-fold increase with vaginal hysterectomy compared to RAL.[39] RAL hysterectomy exhibited lower overall complication rates and higher patient satisfaction. Boggess et al noted decreased morbidity and shorter hospital stays in obese women undergoing RAL hysterectomy, emphasizing its advantages in complex gynecology cases where CL is relatively contraindicated. The ability to perform RAL under ultra-low intra-abdominal pressure (6 mmHg) proved feasible without compromising outcomes, particularly beneficial for patients with poor respiratory compliance and obesity. Sadashivaiah et al. reported successful RAL gynecological surgery in patients with a BMI over 40kg/m^2, with no conversions to laparotomy and a mean length of stay of 1.57 days.[40] Despite higher operating room costs, RAL hysterectomy showed favorable clinical outcomes, including shorter hospital stays, reduced blood loss, fewer conversions to laparotomy, and lower overall complications compared to CL in a meta-analysis of 36 studies.

Role of robotic surgery in urogynaecology

Initially utilized for prolapse surgery, such as sacrocolpopexy and sacrohysteropexy, RAL in urogynaecology has expanded to encompass colposuspension, vesicovaginal fistula management, and addressing mesh/suture complications.[41] The advantages of RAL over conventional laparoscopy include enhanced precision in deep pelvic operations, lower error rates, shorter learning curves, and superior ergonomics.[42] Studies show that RAL sacrocolpopexy offers improved voiding symptoms, enhanced sexual function, and reduced adverse events compared to laparotomy and conventional laparoscopy.[43-45] With a shorter learning curve for gynaecologists with advanced laparoscopic skills, RAL demonstrates efficacy in managing vaginal vault prolapse. Additionally, RAL proves feasible for vesicovaginal fistula care, with over 40 published cases confirming its viability since the first procedure in 2005.[46-48] In recent applications, RAL effectively addresses mesh and suture complications related to midurethral slings and mesh prolapse surgery, providing improved ergonomics and surgical access over traditional laparoscopy, resulting in reported benefits in terms of access, pain, and length of stay.

Role of robotic surgery in gynaecological cancer

RAL hysterectomy is frequently used in gynaecological oncology, primarily for endometrial cancer, and occasionally for cervical cancer and early ovarian cancer restaging.[49] Patients with endometrial cancer often present with comorbidities like severe obesity, diabetes, or hypertension.[50] Challenges in other cancers arise due to the technical complexities of radical surgery. Robotic techniques, particularly developed for procedures challenging with conventional laparoscopy, offer innovative solutions, including exenterative procedures for recurrent cancer.[51]

Endometrial cancer

RCTs and a meta-analysis indicate that for endometrial cancer, CL offers benefits such as a shorter hospital stay, reduced blood loss, and fewer complications compared to laparotomy, without compromising survival.[52,53] CL, however, can pose challenges in patients with significant comorbidities. Robotic surgery has demonstrated a reduction in open operations, complications, and overall costs for endometrial cancer patients, outweighing implementation costs. Studies on endometrial cancer treatment report lower complication and conversion rates, as well as reduced blood loss with RAL compared to CL.[54,55] A Danish study involving 5654 patients revealed improved survival and reduced severe complications after the nationwide introduction of RAL for early-stage endometrial cancer, with MIS utilization increasing from 14% to 72%.[56]

Cervical cancer

MIS techniques, including RAL, have gained widespread acceptance for radical hysterectomy in cervical cancer over the past two decades. A meta-analysis concluded that RAL resulted in fewer complications compared to open surgery.[57] The introduction of robotics in the UK reduced the number of open radical hysterectomies.[58] However, recent studies raised concerns about the efficacy of minimally invasive radical hysterectomy for early-stage cervical cancer, showing lower disease-free and overall survival compared to open surgery.[59,60] In response, the European Society of Gynaecological Oncology recommended open surgery as the gold standard and advised that MIS procedures be recorded and performed by trained surgeons in specialized centers for a subgroup of women.[61] National guidance suggests inconclusive evidence for RAL in tumors smaller than 2 cm, recommending its use only in research contexts.

CONCLUSION

In conclusion, the adoption of RAL in gynecological surgery represents a significant advancement, demonstrating feasibility, safety, and surgeons' preference for more complex procedures. While challenges such as higher costs persist, the ongoing development of new platforms holds promise for addressing this limitation. Improved surgical ergonomics, decreased conversion rates, and positive outcomes in endometriosis, urogynaecology, and endometrial cancer surgery underscore the potential benefits of RAL. As evidence accumulates, emphasizing the comparable or superior postoperative results of RAL in various gynecological procedures, the shift towards minimizing laparotomy becomes evident. The field's future should prioritize investigating long-term cost-effectiveness, considering surgical complexity and patient comorbidities. Additionally, exploring patient perspectives and attitudes towards robotic surgery will be crucial as this innovative field continues to evolve. In promoting minimally invasive approaches, RAL stands as a valuable tool in enhancing operative outcomes, ultimately contributing to improved patient care in gynecological surgery.

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REFERENCES

1. Paraiso MF, Walters MD, Rackley RR, Melek S, Hugney C. Laparoscopic and abdominal sacral colpopexies: a comparative cohort study. Am J Obstet Gynecol. 2005;192(5):1752-8.
2. Mais V, Ajossa S, Guerriero S, Mascia M, Solla E, Melis GB. Laparoscopic versus abdominal myomectomy: a prospective, randomized trial to evaluate benefits in early outcome. Am J Obstet Gynecol. 1996;174(2):654-8.
3. Marescaux J, Rubino F. The ZEUS robotic system: experimental and clinical applications. Surg Clin N Am. 2003;83(6):1305-5.
4. Peplinski R. Past, present and future of the Da Vinci robot," in 2nd UK Robotic Urology Course, Guy's Hospital, London, UK, 2006.
5. Hanna RK, Boggess JF. Applications of surgical robotics in gyneco- logic surgery. In: Rosen J, Hannaford B, Satava R, editors. Surgical robotics. Boston, MA: Springer; 2011: 761-789.
6. Payne TN, Dauterive FR. A comparison of total laparoscopic hyster- ectomy to robotically assisted hysterectomy: surgical outcomes in a community practice. J Minim Invasive Gynecol. 2008;15:286-91.
7. Sorensen SMD, Savran MM, Konge L, Bjerrum F. Three-dimensional versus two-dimensional vision in

laparoscopy: a systematic review. Surg Endosc. 2016;30:11-23.
8. Sahu D, Mathew MJ, Reddy PK. 3D laparoscopy - help or hype; initial experience of a tertiary health Centre. J Clin Diagn Res. 2014;8:NC01-3.
9. Lawrie TA, Liu D, Dowswell T, Song H, Wang L, Shi G. Robot- assisted surgery in gynaecology. Cochrane Database Syst Rev. 2019;4:CD011422.
10. Lonnersford C, Persson J. Implementation and applications of robotic surgery within gynecologic oncology and gynecology: analysis of the first 1000 cases. Ceska Gynekol. 2013;78:12-9.
11. Casarin J, Song C, Multinu F, Cappuccio S, Liu E, Butler KA, et al. Implementing robotic surgery for uterine cancer in the United States: better outcomes without increased costs. Gynecol Oncol. 2020;156:451-8.
12. Stucky CH, Cromwell KD, Voss RK, Chiang YJ, Woodman K, Lee JE, et al. Surgeon symptoms, strain, and selections: systematic review and meta-analysis of surgical ergonomics. Ann Med Surg (Lond). 2018;27:1-8.
13. Hurley AM, Kennedy PJ, O'Connor L, Dinan TG, Cryan JF, Boylan G, et al. SOS save our surgeons: stress levels reduced by robotic surgery. Gynecol Surg. 2015;12:197-206.
14. Bagrodia A, Raman JD. Ergonomics considerations of radical pros- tatectomy: physician perspective of open, laparoscopic, and robot- assisted techniques. J Endourol. 2009;23:627-33.
15. Plerhoples TA, Hernandez-Boussard T, Wren SM. The aching sur- geon: a survey of physical discomfort and symptoms following open, laparoscopic, and robotic surgery. J Robot Surg. 2012;6:65-72.
16. Lawson EH, Curet MJ, Sanchez BR, Schuster R, Berguer R. Postural ergonomics during robotic and laparoscopic gastric bypass surgery: a pilot project. J Robot Surg. 2007;1:61-7.
17. Tarr ME, Brancato SJ, Cunkelman JA, Polcari A, Nutter B, Kenton K. Comparison of postural ergonomics between laparoscopic and robotic sacrocolpopexy: a pilot study. J Minim Inv Gynecol. 2015;22:234-8.
18. Liang Z, Gerull WD, Wang R, Zihni A, Ray S, Awad M. Effect on patient body mass index on laparoscopic surgical ergonomics. Obes Surg. 2019;29:1709-13.
19. AlSabah S, Al Haddad E, Khwaja H. The prevalence of musculoskele- tal injuries in bariatric surgeons. Surg Endosc. 2019;33:1818-27.
20. Partin AW, Adams JB, Moore RG, Kavoussi LR. Complete robot-assisted laparoscopic urologic surgery: a preliminary report. J Am Coll Surg. 1995;181(6):552-7.
21. Kappert U, Schneider J, Cichon R, Gulielmos V, Tugtekin SM, Nicolai J, et al. Development of robotic enhanced endoscopic surgery for the treatment of coronary artery disease. Circulation. 2001;104(12 Suppl 1):I102-7.
22. Goldberg JM, Falcone T. Laparoscopic microsurgical tubal anastomosis with and without robotic assistance. Human Reprod. 2003;18(1):145-7.
23. Dharia Patel SP, Steinkampf MP, Whitten SJ, Malizia BA. Robotic tubal anastomosis: surgical technique and cost effectiveness. Fertility Sterility. 2008;90(4):1175-79.
24. Semm K. New methods of pelviscopy (gynecologic lap- aroscopy) for myomectomy, ovariectomy, tubectomy and adnectomy. Endoscopy. 1979;11(2):85-93.
25. Nezhat C, Lavie O, Lemyre M, Unal E, Nezhat CH, Nezhat F. Robot-assisted laparoscopic surgery in gynecology: scientific dream or reality? Fertility Sterility. 2009;91(6):2620-2.
26. Nezhat C, Saberi NS, Shahmohamady B, Nezhat F. Robotic-assisted laparoscopy in gynecological surgery. J Society Laparoendoscopic Surg. 2006;10(3):317-20.
27. Liu C, Peresic D, Samadi D, Nezhat F. Robotic- assisted laparoscopic partial bladder resection for the treatment of infiltrating endometriosis. J Minimally Invasive Gynecol. 2008;15(6):745-8.
28. M. F. Chammas Jr, F. J. Kim, A. Barbarino et al., “Asymp- tomatic rectal and bladder endometriosis: a case for robotic-assisted surgery,” The Canadian Journal of Urology, vol. 15, no. 3, pp. 4097-4100, 2008.
29. Pundir J, Omanwa K, Kovoor E, Pundir V, Lancaster G, Barton-Smith P. Laparoscopic excision versus ablation for endometriosis-associated pain: an updated systematic review and meta-analysis. J Minim Invasive Gynecol. 2017;24:747-56.
30. Possover M, Andersson K, Forman A. Neuropelveology: an emerging discipline for the management of chronic pelvic pain. Int J Neurourol. 2017;21:243-6.
31. Soto E, Luu TH, Liu X, Magrina JF, Wasson MN, Einarsson JI, et al. Laparoscopy vs. robotic surgery for endometriosis (LAROSE): a multicenter, randomized, controlled trial. Fertil Steril. 2017;107:996-1002.
32. Kondo W, Bourdel N, Tamburro S, Cavoli D, Jardon K, Rabischong B, et al. Complications after surgery for deeply infiltrating pelvic endometriosis. BJOG. 2011;118:292-8.
33. Byrne D, Curnow T, Smith P, Cutner A, Saridogan E, Clark TJ. BSGE Endometriosis Centres Laparoscopic excision of deep rectovaginal endometriosis in BSGE endometriosis centres: a multicenter prospective cohort study. BMJ Open. 2018;8:e018924.
34. Advincula AP, Song A, Burke W, Reynolds RK. Preliminary experience with robot-assisted laparoscopic myomectomy. J Am Assoc Gynecolog Laparoscop. 2004;11(4):511-8.
35. Pitter MC, Anderson P, Blissett A, Pemberton N. Robotic-assisted gynaecological surgery-establishing train- ing criteria; minimizing operative time and blood loss. Int J Med Robotics Comp Assisted Surg. 2008;4(2):114-20.
36. Mao SP, Lai HC, Chang FW, Yu MH, Chang CC. Laparoscopy-assisted robotic myomectomy using the da Vinci system. Taiwanese J Obstetr Gynecol. 2007;46(2):174-6.
37. Bocca S, Stadtmauer L, Oehninger S. Uncomplicated full term pregnancy after da Vinci-assisted laparoscopic myomectomy. Reprod BioMed Online, 2007;14(2):246-9.
38. Patzkowsky KE, As-Sanie S, Advincula AP. Perioperative outcomes of robotic versus laparoscopic hysterectomy for benign disease. JSLS. 2013;17:100-6.
39. Brunes M, Johannesson U, Häbel H, Westergren Soderberg M, Ek M. Effects of obesity on peri-and postoperative outcomes in patients undergoing robotic

versus conventional hysterectomy. J Minim Invasive Gynecol. 2020;28:228-36.
40. Sadashivaiah J, Ahmed D, Gul N. Anaesthetic management of robotic-assisted gynaecology surgery in the morbidly obese - a case series of 46 patients in a UK university teaching hospital. Indian J Anaesth. 2018;62:443-8.
41. O'Sullivan OE, O'Reilly BA. Robot-assisted surgery: impact on gynaecological and pelvic floor reconstructive surgery. Int Urogynecol J. 2012;23:1163-73.
42. D'Souza M, Gendreau J, Feng A, Kim LH, Ho AL, Veeravagu A. Robot-assisted spine surgery: history, efficacy, cost, and future trends. Robot Surg. 2019;6:9-23.
43. Kurdoglu M, Unlu S, Antonetti-Elford M, Kurdoglu Z, Kilic GS. Short-term results of changes in existing and de novo lower urinary tract symptoms after robot-assisted laparoscopic uterosacral ligament suspension and sacrocolpopexy. Low Urin Tract Symptoms. 2019;11:71-7.
44. Van Zanten F, Brem C, Lenters E, Broeders IAMJ, Schrafford Koops SE. Sexual function after robot-assisted prolapse surgery: a prospective study. Int Urogynecol J. 2018;29:905-12.
45. Souders C, Nik-Ahd F, Zhao H, Eilber K, Chugtai B, Anger J. Robotic sacrocolpopexy: adverse events reported to the FDA over the last decade. Int Urogynecol J. 2019;30:1919-23.
46. Grimminck K, Mourik SL, Tjin-Asjoe F, Martens J, Aktas M. Long- term follow-up and quality of life after robot assisted sacrohysteropexy. Eur J Obstet Gynecol Reprod Biol. 2016;206:27-31.
47. Melamud O, Eichel L, Turbow B, Shanberg A. Laparoscopic vesicovaginal fistula repair with robotic reconstruction. Urology. 2005;65:163-6.
48. Occhino JA, Hokenstad ED, Linder BJ. Robot-assisted vesicovaginal fistula repair via a transvesical approach. Int Urogynecol J. 2019;30:327-9.
49. Gallotta V, Cicero C, Conte C, Vizzielli G, Petrillo M, Fagotti A, et al. Robotic versus laparoscopic staging for early ovarian can- cer: a case-matched control study. J Minim Invasive Gynecol. 2017;24:293-8.
50. Moss EL, Morgan G, Martin AP, Sarhanis P, Ind T. Surgical trends, outcomes and disparities in minimal invasive surgery for patients with endometrial cancer in England: a retrospective cohort study. BMJ Open. 2020;10:e036222.
51. Iavazzo C, Gkegkes ID. Robotic technology for pelvic exenteration in cases of cervical cancer. Int J Gynecol Obstet. 2014;125:15-7.
52. Obermaier A, Janda M, Baker J, Kondalsamy-Chennakesavan S, Brand A, Hogg R, et al. Improved surgical safety after laparoscopic compared to open surgery for apparent early stage endometrial cancer; results from a randomized controlled trial. Eur J Cancer. 2012;48:1147-53.
53. Galaal K, Bryant A, Fisher AD, Al-Khaduri M, Kew F, Lopes AD. Laparoscopy versus laparotomy for the management of early stage endometrial cancer. Cochrane Database Syst Rev. 2012;12:CD006655.
54. Leitao MM Jr, Bartashnik A, Wagner I, Lee SJ, Caroline A, Hoskins WJ, et al. Cost-effectiveness analysis of robotically assisted laparoscopy for newly diagnosed uterine cancers. Obstet Gynecol. 2014;123:1031-7.
55. Wright JD, Burke WM, Wilde ET, Lewin SN, Charles AS, Kim JH, et al. Comparative effectiveness of robotic versus laparoscopic hysterectomy for endometrial cancer. J Clin Oncol. 2012;30:783-91.
56. Jorgensen SL, Mogensen O, Wu CS, Korsholm M, Lund K, Jensen PT. Survival after a nationwide introduction of robotic surgery in women with early-stage endometrial cancer: a population-based prospective cohort study. Eur J Cancer. 2019;109:1-11.
57. Shazly SA, Murad MH, Dowdy SC, Gostout BS, Famuyide AO. Robotic radical hysterectomy in early stage cervical cancer: a systematic review and meta-analysis. Gynecol Oncol. 2015;138:457-71.
58. Ind TEJ, Marshall C, Kasius J, Butler J, Barton D, Nobbenhuis M. Introducing robotic radical hysterectomy for stage 1bi cervical can- cer: a prospective evaluation of clinical and economic outcomes in a single UKinstitution. Int J Med Robot. 2019;15:e1970.
59. Ramirez PT, Frumovitz M, Pareja R, Lopez A, Vieira M, Ribeiro R, et al. Minimally invasive versus abdominal radical hysterectomy for cervical cancer. N Engl J Med. 2018;379:1895-904.
60. Melamed A, Margul DJ, Chen L, Keating NL, Del Carmen MG, Yang J, et al. Survival after minimally invasive radical hysterectomy for early-stage cervical cancer. N Engl J Med. 2018;379:1905-14.
61. European Society of Gynaecological Oncology. Laparoscopic radical hysterectomy: an ESGO statement; 2019. Available at: https://www.esgo.org/explore/council/laparoscopic-radical-hysterectomy-an-esgo-statement/. Accessed on 2 February 2021.

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