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Revisiting the application of robotic-assisted surgery in urogynecology and urology

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This article belongs to the Special Issue: Robot-assisted surgery vs. laparoscopy surgery; which is better?"

Abstract

Background: The advancement of minimally invasive surgical techniques has improved patient outcomes and reduced length of hospital stay. This review examines patient outcomes, cost, and efficiency of both the robotic-assisted and laparoscopic approaches to common procedures within urogynecology and urology.
Methods: This is a non-systematic review of the current literature comparing robotic-assisted and laparoscopic gynecologic and urologic procedures. Results: The robotic-assisted techniques are overall less cost-effective and less efficient than laparoscopic approaches without a clear benefit in patient perioperative outcomes. With increasingly complex urologic procedures, such as radical prostatectomy or cystectomy, the robotic approach may improve short term functional outcomes with reduction in blood loss.
Results: The robotic-assisted techniques are overall less cost-effective and less efficient than laparoscopic approaches without a clear benefit in patient perioperative outcomes. With increasingly complex urologic procedures, such as radical prostatectomy or cystectomy, the robotic approach may improve short term functional outcomes with reduction in blood loss.
Conclusion: Both techniques are similar with respect to patient outcomes. Each urologic and urogynecologic surgeon should consider their own preferences, skill level, and the resources of their hospital system when determining surgical approach.
Keywords: minimally invasive surgery, laparoscopy, robotic-assisted surgery, urology, sacrocolpopexy, surgical outcomes

Introduction

The innovation and advancement of minimally invasive techniques in urogynecologic and urologic surgery have enhanced patient outcomes. The traditional open, abdominal procedures have been widely replaced with laparoscopic and robotic approaches that have reduced length of hospital stay and morbidity while improving patient satisfaction [1]. For a patient with advanced stage uterovaginal or vaginal vault prolapse, a mesh-based repair is available without the added risks and longer recovery time inherent to open colpopexies [2]. Likewise, within urology, procedures such as radical prostatectomy, pyeloplasty, and nephrectomies are commonly performed using minimally invasive techniques [3].

With the literature supporting the use of minimally invasive approaches, the advent of the robotic platform then raised a new question: is a robotic or laparoscopic approach preferred for urogynecologic and urologic surgery? Proponents of the laparoscopic technique argue both lower cost and shorter operating times, while the supporters of robotic surgery boast increased surgical dexterity and safety with the bonus of ergonomic advantages. In this review, we aim to critically examine the merits and drawbacks of both robotic and laparoscopic surgery within the context of urogynecology and urology.

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Minimally invasive sacrocolpopexy

One of the more common arenas of debate between approaches is with the sacrocolpopexy for repair of apical predominant pelvic organ prolapse. In the procedure, a lightweight polypropylene mesh is attached to the anterior and posterior walls of the vagina, with the tail of the mesh being anchored to the anterior longitudinal ligament overlying the sacral promontory. This procedure offers increased durability of anatomic outcomes over native tissue repairs.

Specifically, the robotic and laparoscopic approaches to minimally invasive sacrocolpopexy have been compared in both retrospective and prospective fashion. A systematic review in 2016 by Callewaert directly compared the randomized control trials (RTC) by Paraiso *et al*. and Anger *et al*. [4-6]. In the 2011 Paraiso study, 78 patients with post hysterectomy vaginal vault prolapse underwent either laparoscopic or robotic assisted sacrocolpopexy by two academic surgeons with assistance from fellows. The primary outcome of the study was operating time, with breakdown of the time points to include anesthesia time, robot docking time, sacrocolpopexy time, and suturing time. This study showed significantly longer operating times in the robotic group (mean difference 67 minutes, 95% confidence interval [CI] 43–89), $P < 0.001$) [5].

Secondary outcomes included anatomic outcomes and cost. No differences in anatomic outcomes or quality of life measures were seen at 1 year. With cost, the robotic sacrocolpopexy was on average more expensive, with the main increase seen in operating room costs (mean difference $1,667, 95% CI $448–$2,885, $P = 0.008$). Initial purchasing costs or maintenance of the equipment were not included or examined in this study [5].

In the second multi-center RTC performed by Anger *et al*. in 2014, 78 women with stage II or higher pelvic organ prolapse underwent either laparoscopic or robotic sacrocolpopexy with the primary aim to compare cost of procedure. In this study, no difference was found in the initial day of surgery ($12,586 compared with $11,573; $P = 0.160$) between groups. Robotic costs higher when analysis included cost and maintenance of the robot ($19,616 compared with $11,573; $P < 0.001$). Actual sacrocolpopexy procedure time was shorter in the laparoscopic arm than the robotic (178 *vs*. 203 minutes; $P < 0.30$) with no difference seen in total operating time (225 *vs*. 247 minutes $P = 0.110$). No differences at six months were found with anatomic or quality of life outcomes between groups [6].

To present date, a third RTC directly comparing robotic to laparoscopic assisted sacrocolpopexy has been performed. Illiano *et al*. included 100 patients with the primary outcome being prolapse cure rate defined as correction to stage 0 or I prolapse for all compartments. Both groups had a 100% cure rate at 24-month follow-up [7]. The only anatomic difference between the groups was with POP-Q point C/D (-8 cm for robotic group and -7 cm laparoscopic). Notably, there were no differences in secondary outcomes which included symptom severity and intra-operative complication rate. Additionally, Illiano's study showed longer overall procedure time with the robotic arm, including docking time (234.4 +/- 50 *vs*. 192.75 +/- 65 min, $P < 0.001$).

Seror *et al*. also prospectively compared these two procedures in a 2011 study including 67 women and a median follow-up of 16 months [8]. Overall, anatomic repair rate was the same between groups as well as similar, sustained improvements in PDFI-20 scores. The robotic arm had decreased strict operative time, excluded time for preparation and docking of robot (128 *vs.* 231 min, $P < 0.0001$) and decreased blood loss (55 *vs*. 280 mL $P = 0.03$). Importantly, there was no difference in overall operating room time between the groups.

An additional prospective study by Ferrando and Paraiso aimed to compare the application time of Y shaped versus flat mesh configuration using both robotic and laparoscopic approaches [9]. Though the more cost-effective, flat mesh would require the introduction and suturing of two separate mesh components, the authors hypothesized and ultimately concluded no differences in total case or mesh application time. They found a mean case time of 204.4 ± 48 minutes and mean mesh application time of 46.1 minutes. Notably, route of surgery, robotic or laparoscopic, did not contribute to any difference in total case or mesh application time. At 24-month follow-up, there were no differences in objective or subjective prolapse recurrence [10].

Radical prostatectomy and cystectomy

Outside the context of urogynecology and sacrocolpopexy, a notable utilization of robotic assistance in urology is for oncologic procedures. In the randomized control trial LAP-01 by Stolzenburg *et al*., they compared a laparoscopic to robotic approach of radical prostatectomy with the primary outcome of continence recovery at 3 months [11]. Results for this trial favored the robotic-assisted procedure for continence recovery even after controlling for preoperative nerve sparing techniques and age (54% *vs*. 46%, $P = 0.027$). The authors suggest increased precision with the robotic approach contributed to the improved outcomes. A follow-up analysis of the LAP-01 trial examined quality of life outcomes, supported earlier return to functional baseline and social functioning [12].

An additional prospective trial performed by Porpiglia *et al*. in 2013 reported superior continence outcomes in the robotic group [13]. This study included 120 patients and examined continence and potency at 1, 3, 6, and 12-month time points. The continence rate in the robotic group was 80% at 3 months and 61.6% in the laparoscopic group ($P = 0.044$). Supplementing the results of the LAP-01 and the Porpiglia studies, a robust and updated systematic review comparing the approaches suggested that robotic assistance may result in lower overall complication rates with improvements in continence and erectile function recovery [14].

Uniquely, the robotic platform also allows for superimposed MR and CT images during robotic assisted radical prostatectomy [3]. One study demonstrated this by using software to create a 3D virtual reconstruction of the prostate that was then overlaid on the video display in the surgical console [15]. They tout the advantage of this augmented reality as potentially improving surgical decision making and accuracy, however, more oncologic and functional patient outcome data is needed.

In the treatment of bladder cancer, studies have been conducted to compare a laparoscopic versus robotic approach to radical cystectomy. Khan *et al*. in 2012 found that blood transfusions were higher in the robotic group with slightly increased postoperative complication rates, though higher operative time [16]. Though a systematic review including this trial overall supported these conclusions, they cite the significant heterogeneity between studies and the need for more prospective data with long term follow-up for differences in oncologic outcomes [17].

Pyeloplasty

Traditionally an open procedure, performed for congenital or acquired cases of uretero-pelvic obstruction, pyeloplasty is now performed consistently with a minimally invasive approach. Proponents of utilizing robotic assistance for this procedure tout the shorter learning curve with easier tissue handing and suturing compared to conventional laparoscopy. An updated systematic review and meta-analysis by Wang *et al*. in 2013 analyzed twelve studies with a total of 646 patients comparing robotic-assisted versus laparoscopic pyeloplasty [18]. They concluded reduced suturing time with robotic application, but when accounting for docking and un-docking, total operative time remained equivalent. In this review, only one study was prospective and there was marked heterogeneity between the studies [19]. A more recent RTC enrolling pediatric patients, included commentary robotic expenses, citing longer operative times for the laparoscopic approach but higher total cost when robotic assistance was utilized [20]. More updated data and prospective trial in the adult population are needed to make more definitive conclusions on the optimal approach for pyeloplasty.

Nephrectomy

Though the current literature overall supports a robotic approach to radical prostatectomy, the data for nephrectomies mirrors that of sacrocolpopexy in respect to operative times, costs, and outcomes.

Regarding nephrectomies, a retrospective cohort study included 416 US hospitals by Jeong *et al*. in 2017 showed no significant differences in postoperative complications between laparoscopic and robotic-assisted radical nephrectomies [21]. There were prolonged operative times and higher costs in the robotic group. They cite a $2678 difference in mean 90-day direct hospital costs. Despite this, by 2015, 30% of the procedures in the study were robotic consistent with increasing preference for the robotic approach in urology.

Additional reasons for the increasing use of the robotic platform by are related to the enhancement of the technique with advanced technology. For example, near-infrared florescence (NIRF) during robotic surgery can allow better delineation of healthy tissue during partial nephrectomies for renal cell carcinoma [22]. NIRF can also be used to identify ischemic areas of the ureter after injection of indocyanine green (ICG) dye [23].

Outcomes

With sacrocolpopexy, when offering either a robotic-assisted or laparoscopic procedure, there is high quality, prospective evidence to support both the anatomic results as well as the patient reported quality of life factors. This is supported by the systematic review by Callewart *et al*. and Pan *et al*. [4, 24]. Additionally, despite the risk of major vascular or ureteral injury during the sacral dissection, the robotic platform does not provide an obvious safety advantage over traditional laparoscopy [25]. Overall, the review of the urogynecology literature supports both approaches as safe and effective for the management of apical predominant pelvic organ prolapse.

Likewise, the data for both radical and partial nephrectomies mirrors that of sacrocolpopexy in respect to outcomes. A systematic review and meta-analysis by Li *et al.* including 1832 patients showed no differences in blood loss, length of stay, conversion rate, or complications [26]. With increasingly complex urologic procedures, the outcome data is slightly more variable. Especially with radical prostatectomy, the short-term outcomes for continence and potency favor the robotic group [11,13]. This may be due to the increased precision of the robotic approach, which may spare nerves and limit acute blood loss. However, the long-term outcomes show equivalence the laparoscopic approach. A ten-year follow-up of the prospective trial by Porpiglia comparing the procedures demonstrated similar continence and potency rates without differences in oncologic outcomes [27].

Time

In the three randomized control trials to date comparing robotic and laparoscopic sacrocolpopexy, there is overall no time difference between procedures [6, 7, 10]. The exception to this lies in Paraiso's study, which consistently showed lower time requirements for laparoscopy [5]. It is one of the few prospective studies in which time was the primary outcome and is strengthened further by the clear delineation of the time requirements for each portion of the procedure, all shorter with the laparoscopic approach. Docking time, a contributor to longer operating room times with robotics, was an average of 14 minutes. In consideration of the overall efficiency of a day of cases, the total operating room time for each case, "Wheels In to Wheels Out", is arguably the one of the most important factors. This is supported in Paraiso's study, with a 66 minute overall operating room time advantage in the laparoscopic group [5]. Consistent with this finding within the urology literature, robotic assisted nephrectomies, prostatectomies, and pyeloplasties consistently have longer overall operative times [12, 17, 26]. Notably, with increasing complexity of urologic procedures, there does seem to be a time advantage to the robotic platform. A study comparing laparoscopic to robotic ureteric reimplantation found shorter operative times with the robotic approach, 224 versus 187 minutes [28].

Surgeon experience and the factor of a "learning curve" for robotics may also play a role in the variation of robotic time between the studies; however, Paraiso's study also reported stable times for each surgeon across additional cases which serves to weaken this theory. An additional contributing factor to operating room time may be independent of the surgical modality itself and rather a function of the surgical team. Despite attending surgeon experience and individual efficiency, the comfort level of the operating room staff and assistants with the workflow and equipment is a significant factor to the overall time per case. A recent review by Giedelman *et al*. discusses the key steps needed to establish a successful robotic program including room, equipment, and staff recommendations to maximize intraoperative efficiency [29]. When deciding on a laparoscopic or robotic approach for a urogynecological or urologic procedure on operating time alone, it is imperative for the primary surgeon consider the overall capacity of their surgical center to support he or she in their case.

Cost

With one of the main arguments for laparoscopic surgery over robotic surgery being decreased cost. Regarding sacrocolpopexy, our reviewed studies consistently show higher costs with a robotic over laparoscopic approach. Direct comparisons between the trials are challenging, as described by Pan *et al*. because of the variation in the way cost was reported [11]. When the costs differences were most significant, such as in Anger's study, it was when robot purchasing and maintenance fees were included [6]. Additionally, cost increases with robotics have been directly shown to be related to increased operating room time. In a cost minimization analysis by Judd *et al*., robotic and laparoscopic sacrocolpopexies were only equivalent in cost when robotic time was decreased to 149 minutes (a value well below what has been documented in the literature) and laparoscopic time remained at its baseline of 269 minutes [30]. In a retrospective study by Tan-Kim *et al*. in, surgical cost units were calculated based on the additional average of 75 minutes more operating room time with a robotic sacrocolpopexy resulting in an 18% increase in overall cost of procedure [31].

In urology, the trend towards increased robotic radical nephrectomies continues despite these increased costs. Some argue that the uptick in robotic nephrectomies may be the result of smaller hospitals needing to offset their financial investment of a robot with higher case volumes and/or preferential robotic experience in urology residency or fellowship training [21].

Pre-procedure purchasing costs and equipment maintenance certainly contribute to the overall increased expense of robotic surgery for a hospital system. However, one could conclude that the most important factor in real-time cost-mitigation with robotics is based on individual surgeon efficiency.

Ergonomics and skill advantage

An additional important argument for a preference of robotic procedures over laparoscopic is the ergonomical advantage. Regarding physical discomfort, there seems to be overall lower rates experienced by robotic surgeons versus their laparoscopic counterparts [32]. However, there are specific muscle groups that are prone to increased strain with robotics including the neck and trapezius muscles as well as finger pain and eye fatigue, with one study reporting higher symptoms of discomfort with urologic surgeons [33]. Within the gynecology literature, it seems that some of these symptoms can be mitigated with higher confidence in managing ergonomic settings as well as with higher surgical volumes, likely due to consistency with optimal, saved console settings [34]. One study by Tarr *et al*. specifically examined musculoskeletal strain in robotic *vs.* laparoscopic sacrocolpopexy utilizing the Body Part Discomfort (BPD) survey [35]. Their procedure specific data supports the overall body of literature that robotics is the superior ergonomic surgical modality, with lower neck/shoulder and back discomfort BPD scores [35]. For surgeons concerned with overall career longevity limited by musculoskeletal injuries, it may be advantageous to commit to a robotic approach.

Furthermore, robotics may boost individual skill performance and dexterity. Choussein *et al*. found surgical ambidexterity improved when surgeons of multiple skill levels performed on a robotic platform [22]. Time to complete Fundamental of Laparoscopic Surgery (FLS) tasks on robotically nullified the difference in dominant versus non-dominant hand compared to the same tasks performed laparoscopically. An additional study showed that robotic assistance reduced overall rate of errors during performance of FLS tasks all at surgeon experience levels without conferring a significant speed advantage. The robotic platform seems to enhance the precision and dexterity of skills, with improved ergonomics.

Conclusions

Overall, the laparoscopic approach to urogynecologic and urologic procedures, such as the sacrocolpopexy, nephrectomy, and prostatectomy consistently offer lower costs and lower or equivalent operating room times than robotic-assisted procedures without any clear advantage in perioperative safety or long-term outcomes. This review highlights that an efficient and experienced primary surgeon and surgical team can help mitigate costs of robotic procedures by decreasing operating room times. Still, the increased dexterity and ergonomic advantages of robotic surgery during complex procedures may be significant enough factors for some surgeons to prefer robotics. NIRF technology and applications of augmented reality confer additional procedure-specific advantages. In conclusion, each urologic and urogynecologic surgeon should consider their own preferences and resources of their hospital system, while having the confidence that their decision will not significantly affect patient safety or quality of life outcomes.

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References

1. Nielsen JS. The evolution of minimally invasive gynecologic surgery. *Minn Med*, 2012, 95(3): 43-45.
2. Linder BJ, Occhino JA, Habermann EB, Glasgow AE, Bews KA, & Gershman B. A national contemporary analysis of perioperative outcomes of open versus minimally invasive sacrocolpopexy. *J Urol*, 2018, 200(4): 862-867. [Crossref]
3. Navaratnam A, Abdul-Muhsin H, & Humphreys M. Updates in urologic robot assisted surgery. *F1000Res*, 2018, 7. [Crossref]
4. Callewaert G, Bosteels J, Housmans S, Verguts J, Van Cleynenbreugel B, Van der Aa F, *et al.* Laparoscopic versus robotic-assisted sacrocolpopexy for pelvic organ prolapse: a systematic review. *Gynecol Surg*, 2016, 13: 115-123. [Crossref]
5. Paraiso MFR, Jelovsek JE, Frick A, Chen CCG, & Barber MD. Laparoscopic compared with robotic sacrocolpopexy for vaginal prolapse: a randomized controlled trial. *Obstet Gynecol*, 2011, 118(5): 1005-1013. [Crossref]
6. Anger JT, Mueller ER, Tarnay C, Smith B, Stroupe K, Rosenman A, *et al.* Robotic compared with laparoscopic sacrocolpopexy: a randomized controlled trial. *Obstet Gynecol*, 2014, 123(1): 5-12. [Crossref]
7. Illiano E, Ditonno P, Giannitsas K, De Rienzo G, Bini V, & Costantini E. Robot-assisted *vs.* laparoscopic sacrocolpopexy for high-stage pelvic organ prolapse: a prospective, randomized, single-center study. *Urology*, 2019, 134: 116-123. [Crossref]
8. Seror J, Yates DR, Seringe E, Vaessen C, Bitker MO, Chartier-Kastler E, *et al.* Prospective comparison of short-term functional outcomes obtained after pure laparoscopic and robot-assisted laparoscopic sacrocolpopexy. *World J Urol*, 2012, 30(3): 393-398. [Crossref]
9. Ferrando CA, & Paraiso MFR. A prospective randomized trial comparing Restorelle® Y mesh and flat mesh for laparoscopic and robotic-assisted laparoscopic sacrocolpopexy: 24-month outcomes. *Int Urogynecol J*, 2021, 32(6): 1565-1570. [Crossref]
10. Ferrando CA, & Paraiso MFR. A prospective randomized trial comparing restorelle Y mesh and flat mesh for laparoscopic and robotic-assisted laparoscopic sacrocolpopexy. *Female Pelvic Med Reconstr Surg*, 2019, 25(2): 83-87. [Crossref]
11. Stolzenburg JU, Holze S, Neuhaus P, Kyriazis I, Do HM, Dietel A, *et al.* Robotic-assisted versus laparoscopic surgery: outcomes from the first multicentre, randomised, patient-blinded controlled trial in radical prostatectomy (LAP-01). *Eur Urol*, 2021, 79(6): 750-759. [Crossref]
12. Holze S, Lemaire E, Mende M, Neuhaus P, Arthanareeswaran VK, Truss MC, *et al.* Quality of life after robotic-assisted and laparoscopic radical prostatectomy: results of a multicenter randomized controlled trial (LAP-01). *Prostate*, 2022, 82(8): 894-903. [Crossref]
13. Porpiglia F, Morra I, Lucci Chiarissi M, Manfredi M, Mele F, Grande S, *et al.* Randomised controlled trial comparing laparoscopic and robot-assisted radical prostatectomy. *Eur Urol*, 2013, 63(4): 606-614. [Crossref]
14. Ma J, Xu W, Chen R, Zhu Y, Wang Y, Cao W, *et al.* Robotic-assisted versus laparoscopic radical prostatectomy for prostate cancer: the first separate systematic review and meta-analysis of randomised controlled trials and non-randomised studies. *Int J Surg*, 2023, 109(5): 1350-1359. [Crossref]
15. Porpiglia F, Checcucci E, Amparore D, Autorino R, Piana A, Bellin A, *et al.* Augmented-reality robot-assisted radical prostatectomy using hyper-accuracy three-dimensional reconstruction (HA3D™) technology: a radiological and pathological study. *BJU Int*, 2019, 123(5): 834-845. [Crossref]
16. Khan MS, Challacombe B, Elhage O, Rimington P, Coker B, Murphy D, *et al.* A dual-centre, cohort comparison of open, laparoscopic and robotic-assisted radical cystectomy. *Int J Clin Pract*, 2012, 66(7): 656-662. [Crossref]
17. Long J, Wang L, Dong N, Bai X, Chen S, Sun S, *et al.* Robotic-assisted versus standard laparoscopic radical cystectomy in bladder cancer: a systematic review and meta-analysis. *Front Oncol*, 2022, 12: 1024739. [Crossref]
18. Wang F, Xu Y, & Zhong H. Robot-assisted versus laparoscopic pyeloplasty for patients with ureteropelvic junction obstruction: an updated systematic review and meta-analysis. *Scand J Urol*, 2013, 47(4): 251-264.

[Crossref]

19. Link RE, Bhayani SB, & Kavoussi LR. A prospective comparison of robotic and laparoscopic pyeloplasty. *Ann Surg*, 2006, 243(4): 486-491. [Crossref]
20. Silay MS, Danacioglu O, Ozel K, Karaman MI, & Caskurlu T. Laparoscopy versus robotic-assisted pyeloplasty in children: preliminary results of a pilot prospective randomized controlled trial. *World J Urol*, 2020, 38(8): 1841-1848. [Crossref]
21. Jeong IG, Khandwala YS, Kim JH, Han DH, Li S, Wang Y, *et al*. Association of robotic-assisted *vs* laparoscopic radical nephrectomy with perioperative outcomes and health care costs, 2003 to 2015. *JAMA*, 2017, 318(16): 1561-1568. [Crossref]
22. Choussein S, Srouji SS, Farland LV, Wietsma A, Missmer SA, Hollis M, *et al*. Robotic assistance confers ambidexterity to laparoscopic surgeons. *J Minim Invasive Gynecol*, 2018, 25(1): 76-83. [Crossref]
23. Bjurlin MA, Gan M, McClintock TR, Volpe A, Borofsky MS, Mottrie A, *et al*. Near-infrared fluorescence imaging: emerging applications in robotic upper urinary tract surgery. *Eur Urol*, 2014, 65(4): 793-801. [Crossref]
24. Pan K, Zhang Y, Wang Y, Wang Y, & Xu H. A systematic review and meta-analysis of conventional laparoscopic sacrocolpopexy versus robot-assisted laparoscopic sacrocolpopexy. *Int J Gynaecol Obstet*, 2016, 132(3): 284-291. [Crossref]
25. Chang CL, Chen CH, & Chang SJ. Comparing the outcomes and effectiveness of robotic-assisted sacrocolpopexy and laparoscopic sacrocolpopexy in the treatment of pelvic organ prolapse. *Int Urogynecol J*, 2022, 33(2): 297-308. [Crossref]
26. Li J, Peng L, Cao D, Cheng B, Gou H, Li Y, *et al*. Comparison of perioperative outcomes of robot-assisted *vs*. laparoscopic radical nephrectomy: a systematic review and meta-analysis. *Front Oncol*, 2020, 10: 551052. [Crossref]
27. Checcucci E, De Cillis S, Alladio E, Piramide F, Volpi G, Granato S, *et al*. Ten-year functional and oncological outcomes of a prospective randomized controlled trial comparing laparoscopic versus robot-assisted radical prostatectomy. *Prostate*, 2024, 84(9): 832-841. [Crossref]
28. Batra R, Agrawal A, Singh A, Ganpule A, Sabnis R, & Desai M. Laparoscopic ureteric reimplantation versus robotic-assisted laparoscopic ureteric reimplantation for lower ureter pathology: single-institutional comparative study. *Int J Urol*, 2022, 29(11): 1362-1367. [Crossref]
29. Giedelman C, Covas Moschovas M, Bhat S, Brunelle L, Ogaya-Pinies G, Roof S, *et al*. Establishing a successful robotic surgery program and improving operating room efficiency: literature review and our experience report. *J Robot Surg*, 2021, 15(3): 435-442. [Crossref]
30. Judd JP, Siddiqui NY, Barnett JC, Visco AG, Havrilesky LJ, & Wu JM. Cost-minimization analysis of robotic-assisted, laparoscopic, and abdominal sacrocolpopexy. *J Minim Invasive Gynecol*, 2010, 17(4): 493-499. [Crossref]
31. Tan-Kim J, Menefee SA, Luber KM, Nager CW, & Lukacz ES. Robotic-assisted and laparoscopic sacrocolpopexy: comparing operative times, costs and outcomes. *Female Pelvic Med Reconstr Surg*, 2011, 17(1): 44-49. [Crossref]
32. Wee IJY, Kuo LJ, & Ngu JC. A systematic review of the true benefit of robotic surgery: ergonomics. *Int J Med Robot*, 2020, 16(4): e2113. [Crossref]
33. Lee GI, Lee MR, Green I, Allaf M, & Marohn MR. Surgeons' physical discomfort and symptoms during robotic surgery: a comprehensive ergonomic survey study. *Surg Endosc*, 2017, 31(4): 1697-1706. [Crossref]
34. Lee MR, & Lee GI. Does a robotic surgery approach offer optimal ergonomics to gynecologic surgeons?: a comprehensive ergonomics survey study in gynecologic robotic surgery. *J Gynecol Oncol*, 2017, 28(5): e70. [Crossref]
35. 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 Invasive Gynecol*, 2015, 22(2): 234-238. [Crossref]

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