



Literature list to support the LBI HTA on robotic assisted surgery

Radical Prostatectomy

- Comprehensive literature search ORP versus RARP versus LRP – 2010 to 2015
- Study types included: RCTs, prospective comparative studies, systematic reviews with meta-analysis, large (>5000 patients) real world retrospective database studies of established and high quality databases: PREMIERE, SEERS, NSQIP, NIS. HTAs
- This is a comprehensive literature search according to the above mentioned inclusion criteria. The search has been done with rigor, but we make no claim of being complete.

Randomized Controlled Trials (3)

Stolzenburg, J. U., et al. (2015). "Effect of Surgical Approach on Erectile Function Recovery following Bilateral Nerve-Sparing Radical Prostatectomy: An Evaluation Utilizing Data from a Randomized, Double-Blind, Double-Dummy Multicenter Trial of Tadalafil versus Placebo." *BJU International*.

OBJECTIVES: To report pre-specified and exploratory results on the effect of different surgical approaches on erectile function (EF) after nerve-sparing radical prostatectomy (nsRP) obtained from the multicenter, randomized, double-blind, double-dummy REACTT trial of tadalafil (once a day [OaD] or on-demand [pro-re-nata, PRN]) versus placebo. **PATIENTS AND METHODS:** Patients <68yrs with normal preoperative EF who underwent nsRP for localized prostate cancer (Gleason \leq 7, PSA <10ng/mL) were randomized post-nsRP 1:1:1 to 9-month double-blind treatment (DBT) with tadalafil 5mg OaD, tadalafil 20mg PRN, or placebo, followed by 6-week drug-free washout, and 3-month open-label OaD treatment (all patients). EF-recovery was defined as an International Index of Erectile Function (IIEF)-EF domain score \geq 22, and normal orgasmic function was defined based on IIEF Question 10. Both parameters were analyzed at the end of washout using logistic regression including terms for: treatment, country, visit, visit-by-treatment interaction, age group, nerve-sparing score (perfect =2, non-perfect >2), and surgical approach (open surgery, robot-assisted laparoscopy, conventional laparoscopy, other). Time to EF-recovery was analyzed post-hoc with a Cox proportional-hazards model including terms for: treatment, age-group, country, surgical approach, and surgery-by-treatment interaction.

RESULTS: Of 422 patients treated, 189 underwent open surgery, 115 robot-assisted laparoscopy, 88 conventional laparoscopy, and 30 surgery classified as "other". The odds of achieving EF-recovery at the end of drug-free washout were approximately twice as high for the robot-assisted laparoscopy group compared with the open surgery group (odds ratio: 2.42; 95%CI 1.24, 4.72; $p=0.029$). Patients who underwent robot-assisted laparoscopy were significantly more likely to recover during DBT compared with patients who underwent open surgery (hazard ratio: 1.92; 95%CI 1.17, 3.15; $p=0.010$). A favourable effect of conventional laparoscopy compared with open surgery could not be observed. **CONCLUSION:** These results may provide further insights

into the role of surgery on EF-recovery post-nsRP. However, the trial was not designed for these analyses and further prospective studies are needed.

Asimakopoulos, A. D. P. F., C. T.; Annino, F.; Pasqualetti, P.; Calado, A. A.; Mugnier, C. (2011). "Randomized Comparison between Laparoscopic and Robot-Assisted Nerve-Sparing Radical Prostatectomy." *Journal of Sexual Medicine* 8(5): 1503-1512.

Introduction. Lack of randomized controlled trials (RCTs) that compare pure laparoscopic radical prostatectomy (LRP) with robot-assisted laparoscopic radical prostatectomy (RALRP) is an important gap of the literature related to the surgical treatment of the clinically localized prostate cancer (PCa). Aim. To provide the first prospective randomized comparison on the functional and oncological outcomes of LRP and RALRP for the treatment of the clinically localized PCa. Methods. Between 2007 and 2008, 128 consecutive male patients were randomized in two groups and treated by a single experienced surgeon with traditional LRP (Group I-64 patients) or RALRP (Group II-64 patients) in all cases with intent of bilateral intrafascial nerve sparing. Main Outcome Measures. Primary end point was to compare the 12 months erectile function (EF) outcomes. Complication rates, continence outcomes, and oncological results were also compared. The sample size of our study was able, with an adequate power ($1-\beta > 0.90$), to recognize as significant large differences (above 0.30) between incidence proportions of considered outcomes. Results. No statistically significant differences were observed for operating time, estimated blood loss, transfusion rate, complications, rates of positive surgical margins, rates of biochemical recurrence, continence, and time to continence. However, the 12-month evaluation of capability for intercourse (with or without phosphodiesterase type 5 inhibitors) showed a clear and significant advantage of RALRP (32% vs. 77%, $P < 0.0001$). Time to capability for intercourse was significantly shorter for RALRP. Rates of return to baseline International Index of Erectile Function (IIEF-6) EF domain score questionnaires (questions 1-5 and 15) (25% vs. 58%) and to IIEF-6 > 17 (38% vs. 63%) were also significantly higher for RALRP ($P = 0.0002$ and $P = 0.008$, respectively). Conclusions. Our study offers the first high-level evidence that RALRP provides significantly better EF recovery than LRP without hindering the oncologic radicality of the procedure. Larger RCTs are needed to confirm if a new gold-standard treatment in the field of RP has risen. Asimakopoulos AD, Pereira Fraga CT, Annino F, Pasqualetti P, Calado AA, and Mugnier C. Randomized comparison between laparoscopic and robot-assisted nerve-sparing radical prostatectomy. *J Sex Med* 2011;8:1503-1512.

Porpiglia, F. M., I.; Lucci Chiarissi, M.; Manfredi, M.; Mele, F.; Grande, S.; Ragni, F.; Poggio, M.; Fiori, C. (2012). "Randomised Controlled Trial Comparing Laparoscopic and Robot-assisted Radical Prostatectomy." *European Urology*.

Background: The advantages of robot-assisted radical prostatectomy (RARP) over laparoscopic radical prostatectomy (LRP) have rarely been investigated in randomised controlled trials. Objective: To compare RARP and LRP in terms of the functional, perioperative, and oncologic outcomes. The main end point of the study was changes in continence 3 mo after surgery. Design, setting, and participants: From January 2010 to January 2011, 120 patients with organ-confined prostate cancer were enrolled and randomly assigned (using a randomisation plan) to one of two groups based on surgical approach: the RARP group and the LRP group. Intervention: All RARP and LRP interventions were performed with the same technique by the same single surgeon. Outcome measurements and statistical analysis: The demographic, perioperative, and pathologic results, such as the complications and prostate-specific antigen (PSA) measurements, were recorded and compared. Continence was evaluated at the time of catheter removal and 48 h later, and continence and potency were evaluated after 1, 3, 6, and 12 mo. The student t test, Mann-Whitney test, χ^2 test, Pearson χ^2 test, and multiple regression analysis were used for statistics. Results and limitations: The two groups (RARP: $n = 60$; LRP: $n = 60$) were comparable in terms of demographic data. No differences were recorded in terms of perioperative and pathologic results, complication rate, or PSA measurements. The continence rate was higher in

the RARP group at every time point: Continence after 3 mo was 80% in the RARP group and 61.6% in the LRP group ($p = 0.044$), and after 1 yr, the continence rate was 95.0% and 83.3%, respectively ($p = 0.042$). Among preoperative potent patients treated with nerve-sparing techniques, the rate of erection recovery was 80.0% and 54.2%, respectively ($p = 0.020$). The limitations included the small number of patients. Conclusions: RARP provided better functional results in terms of the recovery of continence and potency. Further studies are needed to confirm our results. © 2012.

Systematic Review with Meta-Analysis (8)

Ficarra, V., et al. (2012A). "Systematic Review and Meta-analysis of Studies Reporting Potency Rates After Robot-assisted Radical Prostatectomy." *European Urology* **62**(3): 418-430.

Background: Although the initial robot-assisted radical prostatectomy (RARP) series showed 12-mo potency rates ranging from 70% to 80%, the few available comparative studies did not permit any definitive conclusion about the superiority of this technique when compared with retropubic radical prostatectomy (RRP) and laparoscopic radical prostatectomy (LRP). Objectives: The aims of this systematic review were (1) to evaluate the current prevalence and the potential risk factors of erectile dysfunction after RARP, (2) to identify surgical techniques able to improve the rate of potency recovery after RARP, and (3) to perform a cumulative analysis of all available studies comparing RARP versus RRP or LRP. Evidence acquisition: A literature search was performed in August 2011 using the Medline, Embase, and Web of Science databases. Only comparative studies or clinical series including >100 cases reporting potency recovery outcomes were included in this review. Cumulative analysis was conducted using Review Manager v.4.2 software designed for composing Cochrane Reviews (Cochrane Collaboration, Oxford, UK). Evidence synthesis: We analyzed 15 case series, 6 studies comparing different techniques in the context of RARP, 6 studies comparing RARP with RRP, and 4 studies comparing RARP with LRP. The 12- and 24-mo potency rates ranged from 54% to 90% and from 63% to 94%, respectively. Age, baseline potency status, comorbidities index, and extension of the nerve-sparing procedure represent the most relevant preoperative and intraoperative predictors of potency recovery after RARP. Available data seem to support the use of cautery-free dissection or the use of pinpointed low-energy cauterization. Cumulative analyses showed better 12-mo potency rates after RARP in comparison with RRP (odds ratio [OR]: 2.84; 95% confidence interval [CI]: 1.46-5.43; $p = 0.002$). Only a nonstatistically significant trend in favor of RARP was reported after comparison with LRP (OR: 1.89; $p = 0.21$). Conclusions: The incidence of potency recovery after RARP is influenced by numerous factors. Data coming from the present systematic review support the use of a cautery-free technique. This update of previous systematic reviews of the literature showed, for the first time, a significant advantage in favor of RARP in comparison with RRP in terms of 12-mo potency rates. © 2012.

Ficarra, V., et al. (2012B). "Systematic Review and Meta-analysis of Studies Reporting Urinary Continence Recovery After Robot-assisted Radical Prostatectomy." *European Urology* **62**(3): 405-417.

Context: Robot-assisted radical prostatectomy (RARP) was proposed to improve functional outcomes in comparison with retropubic radical prostatectomy (RRP) or laparoscopic radical prostatectomy (LRP). In the initial RARP series, 12-mo urinary continence recovery rates ranged from 84% to 97%. However, the few available studies comparing RARP with RRP or LRP published before 2008 did not permit any definitive conclusions about the superiority of any one of these techniques in terms of urinary continence recovery. Objective: The aims of this systematic review were (1) to evaluate the prevalence and risk factors for urinary incontinence after RARP, (2) to identify surgical techniques able to improve urinary continence recovery after RARP, and (3) to perform a cumulative analysis of all available studies comparing RARP versus RRP or LRP in terms of the urinary continence recovery rate. Evidence acquisition: A literature search was performed in August 2011 using the Medline, Embase, and Web of Science

databases. The Medline search included only a free-text protocol using the term radical prostatectomy across the title and abstract fields of the records. The following limits were used: humans; gender (male); and publication date from January 1, 2008. Searches of the Embase and Web of Science databases used the same free-text protocol, keywords, and search period. Only comparative studies or clinical series including >100 cases reporting urinary continence outcomes were included in this review. Cumulative analysis was conducted using the Review Manager v.4.2 software designed for composing Cochrane Reviews (Cochrane Collaboration, Oxford, UK). Evidence synthesis: We analyzed 51 articles reporting urinary continence rates after RARP: 17 case series, 17 studies comparing different techniques in the context of RARP, 9 studies comparing RARP with RRP, and 8 studies comparing RARP with LRP. The 12-mo urinary incontinence rates ranged from 4% to 31%, with a mean value of 16% using a no pad definition. Considering a no pad or safety pad definition, the incidence ranged from 8% to 11%, with a mean value of 9%. Age, body mass index, comorbidity index, lower urinary tract symptoms, and prostate volume were the most relevant preoperative predictors of urinary incontinence after RARP. Only a few comparative studies evaluated the impact of different surgical techniques on urinary continence recovery after RARP. Posterior musculofascial reconstruction with or without anterior reconstruction was associated with a small advantage in urinary continence recovery 1 mo after RARP. Only complete reconstruction was associated with a significant advantage in urinary continence 3 mo after RARP (odds ratio [OR]: 0.76; $p = 0.04$). Cumulative analyses showed a better 12-mo urinary continence recovery after RARP in comparison with RRP (OR: 1.53; $p = 0.03$) or LRP (OR: 2.39; $p = 0.006$). Conclusions: The prevalence of urinary incontinence after RARP is influenced by preoperative patient characteristics, surgeon experience, surgical technique, and methods used to collect and report data. Posterior musculofascial reconstruction seems to offer a slight advantage in terms of 1-mo urinary continence recovery. Update of a previous systematic review of literature shows, for the first time, a statistically significant advantage in favor of RARP in comparison with both RRP and LRP in terms of 12-mo urinary continence recovery. © 2012.

Moran, P. S., et al. (2013). "Robot-assisted radical prostatectomy compared with open and laparoscopic approaches: A systematic review and meta-analysis." *International Journal of Urology* **20**(3): 312-321. Medline and Embase were searched for studies comparing robot-assisted radical prostatectomy with open prostatectomy and conventional laparoscopic prostatectomy. Random effects meta-analysis was used to calculate a pooled estimate of effect. The 95% prediction intervals are also reported. One randomized study and 50 observational studies were identified. The results show that compared with open surgery, robot-assisted surgery is associated with fewer positive surgical margins for pT2 tumors (relative risk 0.63, 95% confidence interval 0.49-0.81, $P < 0.001$) and improved outcomes for sexual function at 12 months (relative risk 1.60, 95% confidence interval 1.33-1.93, $P = <0.001$), and, to a lesser extent, urinary function at 12 months (relative risk 1.06, 95% confidence interval 1.02-1.11, $P < 0.01$). Compared with conventional laparoscopic prostatectomy, robot-assisted surgery is associated with a slight increase in urinary function at 12 months (relative risk 1.09, 95% confidence interval 1.02 to 1.17, $P = 0.013$). The overall methodological quality of the included studies was low, with high levels of heterogeneity. The use of prediction intervals as an aid to decision making in regard to the introduction of this technology is examined. Clinically significant improvements in positive surgical margins rates for pT2 tumors and sexual function at 12 months associated with robot-assisted surgery in comparison with open surgery should be interpreted with caution given the limitations of the evidence. Differences between robot-assisted and conventional laparoscopic surgery are minimal.

Novara, G., et al. (2012A). "Systematic Review and Meta-analysis of Studies Reporting Oncologic Outcome After Robot-assisted Radical Prostatectomy." *European Urology*.

Context: Despite the large diffusion of robot-assisted radical prostatectomy (RARP), literature and data on the oncologic outcome of RARP are limited. Objective: Evaluate lymph node yield,

positive surgical margins (PSMs), use of adjuvant therapy, and biochemical recurrence (BCR)-free survival following RARP and perform a cumulative analysis of all studies comparing the oncologic outcomes of RARP and retropubic radical prostatectomy (RRP) or laparoscopic radical prostatectomy (LRP). Evidence acquisition: A systematic review of the literature was performed in August 2011, searching Medline, Embase, and Web of Science databases. A free-text protocol using the term radical prostatectomy was applied. The following limits were used: humans; gender (male); and publications dating from January 1, 2008. A cumulative analysis was conducted using Review Manager software v.4.2 (Cochrane Collaboration, Oxford, UK) and Stata 11.0 SE software (StataCorp, College Station, TX, USA). Evidence synthesis: We retrieved 79 papers evaluating oncologic outcomes following RARP. The mean PSM rate was 15% in all comers and 9% in pathologically localized cancers, with some tumor characteristics being the most relevant predictors of PSMs. Several surgeon-related characteristics or procedure-related issues may play a major role in PSM rates. With regard to BCR, the very few papers with a follow-up duration >5 yr demonstrated 7-yr BCR-free survival estimates of approximately 80%. Finally, all the cumulative analyses comparing RARP with RRP and comparing RARP with LRP demonstrated similar overall PSM rates (RARP vs RRP: odds ratio [OR]: 1.21; $p = 0.19$; RARP vs LRP: OR: 1.12; $p = 0.47$), pT2 PSM rates (RARP vs RRP: OR: 1.25; $p = 0.31$; RARP vs LRP: OR: 0.99; $p = 0.97$), and BCR-free survival estimates (RARP vs RRP: hazard ratio [HR]: 0.9; $p = 0.526$; RARP vs LRP: HR: 0.5; $p = 0.141$), regardless of the surgical approach. Conclusions: PSM rates are similar following RARP, RRP, and LRP. The few data available on BCR from high-volume centers are promising, but definitive comparisons with RRP or LRP are not currently possible. Finally, significant data on cancer-specific mortality are not currently available. © 2012.

Novara, G., et al. (2012B). "Systematic Review and Meta-analysis of Perioperative Outcomes and Complications After Robot-assisted Radical Prostatectomy." European Urology.

Context: Perioperative complications are a major surgical outcome for radical prostatectomy (RP). Objective: Evaluate complication rates following robot-assisted RP (RARP), risk factors for complications after RARP, and surgical techniques to improve complication rates after RARP. We also performed a cumulative analysis of all studies comparing RARP with retropubic RP (RRP) or laparoscopic RP (LRP) in terms of perioperative complications. Evidence acquisition: A systematic review of the literature was performed in August 2011, searching Medline, Embase, and Web of Science databases. A free-text protocol using the term radical prostatectomy was applied. The following limits were used: humans; gender (male); and publications dating from January 1, 2008. A cumulative analysis was conducted using Review Manager software v.4.2 (Cochrane Collaboration, Oxford, UK). Evidence synthesis: We retrieved 110 papers evaluating oncologic outcomes following RARP. Overall mean operative time is 152 min; mean blood loss is 166 ml; mean transfusion rate is 2%; mean catheterization time is 6.3 d; and mean in-hospital stay is 1.9 d. The mean complication rate was 9%, with most of the complications being of low grade. Lymphocele/lymphorrea (3.1%), urine leak (1.8%), and reoperation (1.6%) are the most prevalent surgical complications. Blood loss (weighted mean difference: 582.77; $p < 0.00001$) and transfusion rate (odds ratio [OR]: 7.55; $p < 0.00001$) were lower in RARP than in RRP, whereas only transfusion rate (OR: 2.56; $p = 0.005$) was lower in RARP than in LRP. All the other analyzed parameters were similar, regardless of the surgical approach. Conclusions: RARP can be performed routinely with a relatively small risk of complications. Surgical experience, clinical patient characteristics, and cancer characteristics may affect the risk of complications. Cumulative analyses demonstrated that blood loss and transfusion rates were significantly lower with RARP than with RRP, and transfusion rates were lower with RARP than with LRP, although all other features were similar regardless of the surgical approach. © 2012.

Pan, X. W., et al. (2014). "Robot-Assisted Radical Prostatectomy vs. Open Retropubic Radical Prostatectomy for Prostate Cancer: A Systematic Review and Meta-analysis." Indian Journal of Surgery.

Open retropubic radical prostatectomy (ORP) remains the "gold standard" for surgical treatment of clinically localized prostate cancer (PCa). Robot-assisted radical prostatectomy (RARP) is a

robotic surgery used worldwide. The aim of this study is to collect the data available in the literature on RARP and ORP, and further evaluate the overall safety and efficacy of RARP vs. ORP for the treatment of clinically localized PCa. A literature search was performed using electronic databases between January 2009 and October 2013. Clinical data such as operation duration, transfusion rate, positive surgical margins (PSM), nerve sparing, 3- and 12-month urinary continence, and potency were pooled to carry out meta-analysis. Six studies were enrolled for this meta-analysis. The operation duration of RARP group was longer than that of ORP group (weighted mean difference = 64.84). There was no statistically significant difference in the transfusion rate, PSM rate, and between RARP and ORP (transfusion rate, OR = 0.30; PSM rate, OR = 0.94). No significant difference was seen in 3- and 12-month urinary continence recovery (3 months, OR = 1.32; 12 months, OR = 1.30). There was a statistically significant difference in potency between the 3- and 12-month groups (3 months, OR = 2.80; 12 months, OR = 1.70). RARP is a safe and feasible surgical technique for the treatment of clinically localized PCa owing to the advantages of fewer perioperative complications and quicker patency recovery.

Robertson, C., et al. (2013). "Relative effectiveness of robot-assisted and standard laparoscopic prostatectomy as alternatives to open radical prostatectomy for treatment of localised prostate cancer: a systematic review and mixed treatment comparison meta-analysis." *BJU International* 112(6): 798-812.

OBJECTIVE: To compare the effectiveness of robot-assisted and standard laparoscopic prostatectomy. METHODS: A care pathway was described. We performed a systematic literature review based on a search of Medline, Medline in Process, Embase, Biosis, Science Citation Index, Cochrane Controlled Trials Register, Current Controlled Trials, Clinical Trials, WHO International Clinical Trials Registry and NIH Reporter, the Health Technology Assessment databases, the Database of Abstracts of Reviews of Effects, and relevant conference abstracts up to 31st October 2010). Additionally, reference lists were scanned, an expert panel consulted, and websites of manufacturers, professional organisations, and regulatory bodies were checked. We selected randomised controlled trials (RCTs) and non-randomised comparative studies, published after 1st January 1995, including men with localised prostate cancer undergoing robot-assisted or laparoscopic prostatectomy compared with the other procedure or with open prostatectomy. Studies where at least 90% of included men had clinical tumour stages T1 to T2 and which reported at least one of our specified outcomes were eligible for inclusion. A mixed-treatment comparison meta-analysis was performed to generate comparative statistics on specified outcomes. RESULTS: We included data from 19 064 men across one RCT and 57 non-randomised comparative reports. Robotic prostatectomy had a lower risk of major intra-operative harms such as organ injury [0.4% robotic vs 2.9% laparoscopic], odds ratio ([OR] {95% credible interval [CrI]} 0.16 [0.03 to 0.76]), and a lower rate of surgical margins positive for cancer [17.6% robotic vs 23.6% laparoscopic], OR [95% CrI] 0.69 [0.51 to 0.96]). There was no evidence of a difference in the proportion of men with urinary incontinence at 12 months (OR [95% CrI] 0.55 [0.09 to 2.84]). There were insufficient data on sexual dysfunction. Surgeon learning rates for the procedures did not differ, although data were limited. CONCLUSIONS: Men undergoing robotic prostatectomy appear to have reduced surgical morbidity, and a lower risk of a positive surgical margin, which may reduce rates of cancer recurrence and the need for further treatment, but considerable uncertainty surrounds these results. We found no evidence that men undergoing robotic prostatectomy are disadvantaged in terms of early outcomes. We were unable to determine longer-term relative effectiveness.

Tewari, A., et al. (2012). "Positive Surgical Margin and Perioperative Complication Rates of Primary Surgical Treatments for Prostate Cancer: A Systematic Review and Meta-Analysis Comparing Retropubic, Laparoscopic, and Robotic Prostatectomy." *European Urology* 62(1): 1-15.

Context: Radical prostatectomy (RP) approaches have rarely been compared adequately with regard to margin and perioperative complication rates. Objective: Review the literature from 2002 to 2010 and compare margin and perioperative complication rates for open retropublic RP (ORP), laparoscopic RP (LRP), and robot-assisted LRP (RALP). Evidence acquisition: Summary data were abstracted from 400 original research articles representing 167 184 ORP, 57 303 LRP, and 62 389 RALP patients (total: 286 876). Articles were found through PubMed and Scopus searches and met a priori inclusion criteria (eg, surgery after 1990, reporting margin rates and/or perioperative complications, study size >25 cases). The primary outcomes were positive surgical margin (PSM) rates, as well as total intra- and perioperative complication rates. Secondary outcomes included blood loss, transfusions, conversions, length of hospital stay, and rates for specific individual complications. Weighted averages were compared for each outcome using propensity adjustment. Evidence synthesis: After propensity adjustment, the LRP group had higher positive surgical margin rates than the RALP group but similar rates to the ORP group. LRP and RALP showed significantly lower blood loss and transfusions, and a shorter length of hospital stay than the ORP group. Total perioperative complication rates were higher for ORP and LRP than for RALP. Total intraoperative complication rates were low for all modalities but lowest for RALP. Rates for readmission, reoperation, nerve, ureteral, and rectal injury, deep vein thrombosis, pneumonia, hematoma, lymphocele, anastomotic leak, fistula, and wound infection showed significant differences between groups, generally favoring RALP. The lack of randomized controlled trials, use of margin status as an indicator of oncologic control, and inability to perform cost comparisons are limitations of this study. Conclusions: This meta-analysis demonstrates that RALP is at least equivalent to ORP or LRP in terms of margin rates and suggests that RALP provides certain advantages, especially regarding decreased adverse events. © 2012 European Association of Urology.

Prospective Comparative Studies (11)

Asimakopoulos, A. D., et al. (2013). "Laparoscopic versus robot-assisted bilateral nerve-sparing radical prostatectomy: comparison of pentapecta rates for a single surgeon." Surgical Endoscopy.

BACKGROUND: This study aimed to compare the pentapecta rates between laparoscopic radical prostatectomy (LRP) and robot-assisted radical prostatectomy (RALP) and to identify prognostic factors predicting the pentapecta for each technique. METHODS: This prospective comparative study enrolled 248 consecutive male patients 70 years of age or younger with clinically localized prostate cancer [PCa: age \leq 70 years, prostate-specific antigen (PSA) \leq 10 ng/ml, biopsy Gleason score \leq 7] who were fully continent, potent, and candidates for bilateral nerve-sparing (BNS) LRP or RALP. The pentapecta rates between LRP and RALP were compared. A logistic regression model was created to evaluate independent factors for achieving pentapecta.

RESULTS: In the final analysis, 91 LRP and 136 RALP patients were evaluated. The median follow-up period was 21 months for the 91 LRP patients and 18 months for the 136 RALP patients ($p = 0.07$). Of the 227 patients, 87 reached pentapecta [25 LRP patients (27.5 %) vs 62 RALP patients (45.6 %), $p = 0.006$]. Of the 140 patients who failed pentapecta, 90 (64.3 %) missed a single parameter, and the difference between the groups was significant (80 % LRP vs 53.3 % RALP, $p = 0.007$). Lower age, lower pathologic stage, and RALP are significantly associated with pentapecta as independent factors. For the pT3 disease, the two techniques did not differ significantly. CONCLUSIONS: Patients submitted to BNS RP have low possibilities of achieving pentapecta. Use of the robotic platform by a single surgeon significantly enhances the possibility of achieving pentapecta independently of age and pathologic stage. Potency was the most difficult outcome to reach after surgery, and it was the main factor leading to pentapecta failure. LRP and RALP provide equivalent pentapecta rates for the pT3 disease and similar "tetrapecta" outcomes when potency recovery is not included among the postoperative expectations of the patient.

Davison, B. J., et al. (2014). "Prospective comparison of the impact of robotic-assisted laparoscopic radical prostatectomy versus open radical prostatectomy on health-related quality of life and decision regret." *Canadian Urological Association Journal* **8**(1-2): E68-72.

INTRODUCTION: There is no conclusive evidence that the robotic-assisted laparoscopic radical prostatectomy (RARP) is superior to conventional open radical prostatectomy (ORP) when it comes to recovery of urinary and sexual function, and that the former surgical option results in less decision regret. METHODS: Patients scheduled for both surgical procedures were surveyed prior to surgery, and then again at 6 and 12 months following treatment using the sexual and urinary modules of the Expanded Prostate Cancer Index Composite (EPIC) measure. Decision regret was measured at 12 months. Propensity score regression adjustment was used to account for differences between treatment groups by summarizing all covariate information into a single probability and to simulate randomization. RESULTS: At 12 months, urinary summary scores approached baseline levels, while urinary bother scores had returned to baseline. Sexual summary and bother mean scores decreased by about half of what they were at baseline for both treatment groups at 6 and 12 months. No significant differences in the groups' sexual summary and bother domains were identified at either 6 or 12 months. Both groups' scores for decision regret were low. Moderate correlations (r^2 range -0.333 to -0.368) were between current levels of urinary and sexual function and decision regret at 12 months. CONCLUSION: The results of our study found no significant difference in health-related quality of life outcomes based on surgical procedure at 12 months. Moreover, patients in both groups reported low levels of decision regret at 12 months. Further multi-site prospective studies are required to address this study's limitations.

Deffar, N., et al. (2013). "[Erectile function and sexuality of partners after radical prostatectomy with robotics versus manual laparoscopy: long-term assessment]." *Progres en Urologie* **23**(1): 42-49.

OBJECTIVE: To compare the long-term sexual outcome of laparoscopic radical prostatectomy (LRP) vs robot-assisted laparoscopic prostatectomy (RALP). PATIENTS AND METHODS: A questionnaire was sent to the 412 patients treated by the same surgeon by LRP or RALP from March 2004 to July 2009. Ninety-six patients were evaluated preoperatively with a good erectile function before surgery and a follow-up more than 24 months. Erectile function was evaluated by the IIEF-5, the QLQ-C30 PR25 questionnaires. Partner's sexuality was evaluated with a FSFI's based questionnaire. RESULTS: There was no significant difference before surgery between two groups LRP and RALP. After surgery, the IIEF-5 without any treatment was better in RALP group than in LRP group ($P=0.025$). When a bilateral nerve sparing was performed, the IIEF-5 maximum was better in RALP group ($P=0.002$). For the partners, there was no difference between the two techniques and it appeared that communication about sexuality is the less altered, long time after a radical prostatectomy. CONCLUSIONS: In case of bilateral nerve sparing prostatectomy, an experimented operator in laparoscopic surgery should have better long-term erectile function results with RALP than LRP. Partner's sexuality modifications need more prospective studies to know its influence on erectile rehabilitation.

Di Pierro, G. B. B., P.; Stucki, P.; Beatrice, J.; Danuser, H.; Mattei, A. (2011). "A prospective trial comparing consecutive series of open retropubic and robot-assisted laparoscopic radical prostatectomy in a centre with a limited caseload." *European Urology* **59**(1): 1-6.

Background: Robot-assisted radical prostatectomy (RALP) is performed worldwide, even in institutions with limited caseloads. However, although the results of large RALP series are available, oncologic and functional outcomes as well as complications from low-caseload centres are lacking. Objective: To compare perioperative, oncologic, and functional outcomes from two consecutive series of patients with localised prostate cancer treated by retropubic radical prostatectomy (RRP) or recently established RALP in our hospital, which has a limited caseload. Design, setting, and participants: One hundred fifty consecutive patients were enrolled. Their data and outcomes were collected and extensively evaluated. Intervention: Seventy-five consecutive patients underwent RRP, and 75 consecutive patients underwent RALP, including all

patients of the learning curve. Measurements: Patient baseline characteristics, perioperative and postoperative outcomes, and complications were evaluated. End points were oncologic data (positive margins, prostate-specific antigen [PSA]), perioperative complications, urinary continence, and erectile function at 3- and 12-mo follow-up. Results and limitations: The preoperative parameters from the two groups were comparable. The positive surgical margin (PSM) rates were 32% for RRP and 16% for RALP ($p = 0.002$). For RRP and RALP, the PSA value was <0.2 ng/ml in 91% and 88% of patients 3 mo postoperatively ($p = 0.708$) and in 87% and 89% of patients 12 mo postoperatively ($p = 0.36$), respectively. Continence rates for RRP and RALP were 83% and 95% at 3-mo follow-up ($p = 0.003$) and 80% and 89% after 12-mo follow-up ($p = 0.092$), respectively. Among patients who were potent without phosphodiesterase type 5 inhibitors (PDE5-I) before RRP and RALP, recovery of erectile function with and without PDE5-Is was achieved in 25% (12 of 49 patients) and 68% (25 of 37 patients) 3 mo postoperatively ($p = 0.009$) and in 26% (12 of 47 patients) and 55% (12 of 22 patients) 12 mo postoperatively ($p = 0.009$), respectively. Minimal follow-up for RRP was 12 mo; median follow-up for the RALP group was 12 mo (range: 3-12). According to the modified Clavien system, major complication rates for RRP and RALP were 28% and 7% ($p = 0.025$), respectively; minor complication rates were 24% and 35% ($p = 0.744$), respectively. Conclusions: Despite a limited caseload and including the learning curve, RALP offers slightly better results than RRP in terms of PSM, major complications, urinary continence, and erectile function. © 2010 European Association of Urology.

Geraerts, I., et al. (2013). "Prospective evaluation of urinary incontinence, voiding symptoms and quality of life after open and robot-assisted radical prostatectomy." BJU International.

OBJECTIVE: To compare functional outcomes, i.e. urinary incontinence (UI), voiding symptoms and quality of life, after open (ORP) and robot-assisted radical prostatectomy (RARP). PATIENTS AND METHODS: Between September 2009 and July 2011, 180 consecutive patients underwent radical prostatectomy; of these, 116 underwent ORP and 64 underwent RARP. We prospectively assessed the functional outcomes of each group during the first year of follow-up. We measured UI on the 3 days before surgery (24-h pad test) and daily after surgery until total continence, defined as 3 consecutive days of 0 g urine leak, was achieved. Additionally, all patients were assessed before surgery and at 1, 3, 6 and 12 months after surgery using the International Prostate Symptom Score (IPSS) and the King's Health Questionnaire (KHQ). All patients received pelvic floor muscle training until continence was achieved. Kaplan-Meier analyses and Cox regression with correction for covariates were used to compare time to continence. A Mann-Whitney U-test was used to assess IPSS and KHQ. RESULTS: Patients in the RARP group had a significantly lower D'Amico risk group allocation and underwent more nerve-sparing surgery. Other characteristics were similar. Patients in the RARP group regained continence sooner than those in the ORP group ($P = 0.007$). In the RARP group, the median time to continence (16 vs 46 days, $P = 0.026$) was significantly shorter and the median amount of first day UI (44 vs 186 g, $P < 0.01$) was significantly smaller than in the ORP group. After correction for all covariates, the difference remained significant ($P = 0.036$, hazard ratio [HR] 1.522 (1.027-2.255)). In addition, younger men, men with positive surgical margins and men without preoperative incontinence achieved continence sooner. A comparison of time to continence between groups with a sufficient number of patients (intermediate risk and/or bilateral nerve-sparing) still showed a faster return of continence after RARP, but the effect decreased in size and was nonsignificant ($HR > 1.2$, $P > 0.05$). Only six patients (two in the RARP and four in the ORP group) still had UI after 1 year. Patients in the RARP group had significantly better IPSS scores at 1 ($P = 0.013$) and 3 ($P = 0.038$) months, and scored better in almost all KHQ aspects. CONCLUSION: In this prospective trial, patients treated with RARP tended to regain urinary continence sooner than patients treated with ORP, but in subgroup analyses statistical significance disappeared and effect size decreased dramatically, indicating that the results must be interpreted with caution.

Hagiland, E., et al. (2015). "Urinary Incontinence and Erectile Dysfunction After Robotic Versus Open Radical Prostatectomy: A Prospective, Controlled, Nonrandomised Trial." European Urology.

Background: Robot-assisted laparoscopic radical prostatectomy (RALP) has become widely used without high-grade evidence of superiority regarding long-term clinical outcomes compared with open retropubic radical prostatectomy (RRP), the gold standard. Objective: To compare patient-reported urinary incontinence and erectile dysfunction 12 mo after RALP or RRP. Design, setting, and participants: This was a prospective, controlled, nonrandomised trial of patients undergoing prostatectomy in 14 centres using RALP or RRP. Clinical-record forms and validated patient questionnaires at baseline and 12 mo after surgery were collected. Outcome measurements and statistical analyses: Odds ratios (ORs) were calculated with logistic regression and adjusted for possible confounders. The primary end point was urinary incontinence (change of pad less than once in 24. h vs one time or more per 24. h) at 12 mo. Secondary end points were erectile dysfunction at 12 mo and positive surgical margins. Results and limitations: Of 2625 eligible men, 2431 (93%) could be evaluated for the primary end point. At 12 mo after RALP, 366 men (21.3%) were incontinent, as were 144 (20.2%) after RRP. The adjusted OR was 1.08 (95% confidence interval [CI], 0.87-1.34). Erectile dysfunction was observed in 1200 men (70.4%) 12 mo after RALP and 531 (74.7%) after RRP. The adjusted OR was 0.81 (95% CI, 0.66-0.98). The frequency of positive surgical margins did not differ significantly between groups: 21.8% in the RALP group and 20.9% in the RRP group (adjusted OR: 1.09; 95% CI, 0.87-1.35). The nonrandomised design is a limitation. Conclusions: In a Swedish setting, RALP for prostate cancer was modestly beneficial in preserving erectile function compared with RRP, without a statistically significant difference regarding urinary incontinence or surgical margins. Patient summary: We compared patient-reported urinary incontinence after prostatectomy with two types of surgical technique. There was no statistically significant improvement in the rate of urinary leakage, but there was a small improvement regarding erectile function after robot-assisted operation. Robot-assisted laparoscopic radical prostatectomy did not statistically significantly improve urinary continence compared with open prostatectomy 12 mo after surgery. Erectile function remained intact in statistically significantly more patients operated with the robot-assisted technique; the difference was modest. © 2015 European Association of Urology.

Hong, J. Y. K., J. Y.; Choi, Y. D.; Rha, K. H.; Yoon, S. J.; Kil, H. K. (2010). "Incidence of venous gas embolism during robotic-assisted laparoscopic radical prostatectomy is lower than that during radical retropubic prostatectomy." *British Journal of Anaesthesia*.

BACKGROUND: /st> Robotic-assisted laparoscopic radical prostatectomy (RALRP) is gaining popularity as a less traumatic and minimally invasive alternative to open radical retropubic prostatectomy (RRP). The aim of this study was to evaluate the incidence and grade of venous gas embolism (VGE) during RALRP compared with those during RRP using transoesophageal echocardiography (TOE). METHODS: /st> Fifty-two patients undergoing RRP (n=26) or RALRP (n=26) were consecutively enrolled. TOE was continuously applied during surgery and VGE was graded by an independent researcher. RESULTS: /st> The total incidence of VGE (proportion, 95% CI) in the RRP group was higher than that in the RALRP group [20/25 (0.80, 0.60-0.92) and 10/26 (0.38, 0.22-0.58), respectively]. Most VGE in the RALRP group occurred during the transection of the deep dorsal venous complex. There was no difference in the incidence of severe VGE between the two groups. No patients with cardiorespiratory instabilities even with severe VGE were observed in this study. CONCLUSIONS: /st> In contrast to general belief, VGE occurred less frequently during RALRP. Although the VGE in this study did not cause any cardiorespiratory instability, close monitoring for possibly fatal VGE must be considered during both types of radical prostatectomy because those who undergo radical prostatectomy frequently have cardiopulmonary co-morbidities.

Park, B., et al. (2013). "Comparison of oncological and functional outcomes of pure versus robotic-assisted laparoscopic radical prostatectomy performed by a single surgeon." *Scand J Urol* **47**(1): 10-18. OBJECTIVE: The aim of this study was to compare oncological and functional outcomes of pure laparoscopic radical prostatectomy (LRP) and robotic-assisted laparoscopic radical prostatectomy

(RALRP) performed by a single surgeon. MATERIAL AND METHODS: In total, 327 consecutive patients with prostate cancer who underwent radical prostatectomy (144 with LRP and 183 with RALRP) were enrolled. No significant differences were found in prostate-specific antigen level, biopsy Gleason score, clinical T stage or D'Amico risk stratification between the two groups. The operating time was longer in the LRP group ($p < 0.001$). The RALRP group patients had significantly lower postoperative pain numerical rating scale (NRS) ($p = 0.016$) and catheter duration ($p < 0.001$). There were no differences in pathological Gleason score, pathological T stage or positive surgical margin rate. No differences were found in biochemical recurrence-free survival. Postoperative pad-free continence rates revealed a more rapid recovery in the RALRP group, but rates at 12 months were not significantly different. Multivariate analysis showed that the type of surgery was a strong independent factor to predict early postoperative pad use. Postoperative potency rates were not significantly different at 3, 6 and 12 months in patients who underwent nerve-sparing procedures. CONCLUSIONS: LRP and RALRP performed by a single surgeon yielded similar results in terms of safety and oncological outcomes. More favorable outcomes were noted in operating time, pain NRS and catheter duration, as well as urinary continence recovery time. Therefore, RALRP showed more favorable components in terms of postoperative quality of life than LRP.

Silberstein, J. L. V., A. J.; Power, N. E.; Parra, R. O.; Coleman, J. A.; Pinochet, R.; Touijer, K. A.; Scardino, P. T.; Eastham, J. A.; Laudone, V. P. (2011). "Pelvic Lymph Node Dissection for Patients with Elevated Risk of Lymph Node Invasion during Radical Prostatectomy: Comparison of Open, Laparoscopic and Robot-Assisted Procedures." Journal of Endourology.

Abstract Background and Purpose: Published outcomes of pelvic lymph node dissection (PLND) during robot-assisted laparoscopic prostatectomy (RALP) demonstrate significant variability. The purpose of the study was to compare PLND outcomes in patients at risk for lymph node involvement (LNI) who were undergoing radical prostatectomy (RP) by different surgeons and surgical approaches. Patients and Methods: Institutional policy initiated on January 1, 2010, mandated that all patients undergoing RP receive a standardized PLND with inclusion of the hypogastric region when predicted risk of LNI was $\geq 2\%$. We analyzed the outcomes of consecutive patients meeting these criteria from January 1 to September 1, 2010 by surgeons and surgical approach. All patients underwent RP; surgical approach (open radical retropubic [ORP], laparoscopic [LRP], RALP) was selected by the consulting surgeon. Differences in lymph node yield (LNY) between surgeons and surgical approaches were compared using multivariable linear regression with adjustment for clinical stage, biopsy Gleason grade, prostate-specific antigen (PSA) level, and age. Results: Of 330 patients (126 ORP, 78 LRP, 126 RALP), 323 (98%) underwent PLND. There were no significant differences in characteristics between approaches, but the nomogram probability of LNI was slightly greater for ORP than RALP ($P=0.04$). LNY was high (18 nodes) by all approaches; more nodes were removed by ORP and LRP (median 20, 19, respectively) than RALP (16) after adjusting for stage, grade, PSA level, and age ($P=0.015$). Rates of LNI were high (14%) with no difference between approaches when adjusted for nomogram probability of LNI ($P=0.15$). Variation in median LNY among individual surgeons was considerable for all three approaches (11-28) ($P=0.005$) and was much greater than the variability by approach. Conclusions: PLND, including hypogastric nodal packet, can be performed by any surgical approach, with slightly different yields but similar pathological outcomes. Individual surgeon commitment to PLND may be more important than approach.

Tyritzis, S. I., et al. (2014). "Thromboembolic complications in 3544 patients undergoing radical prostatectomy with or without lymph node dissection." Journal of Urology.

BACKGROUND: Lymph node dissection (LND) in prostate cancer patients may increase complications. An association of LND with thromboembolic events has been suggested. We compared the incidence and investigated predictors of deep venous thrombosis (DVT) and

pulmonary embolism (PE) among other complications in patients undergoing or not undergoing LND during open (ORP) and robot-assisted laparoscopic radical prostatectomy (RARP) METHODS: 3544 patients were included between 2008-2011. The cohort derives from LAPPRO, a multi-center, prospective controlled trial. Data concerning adverse events were extracted from patient-completed questionnaires. Our primary outcome was prevalence of DVT and/or PE. Secondary outcomes were other types of 90-day adverse events and re-admission causes. RESULTS: 547 (15.4%) patients underwent LND. LND was associated with an 8-fold and 6-fold higher risk of DVT and PE events, respectively, compared to the no-LND patients [RR 95%CI: 7.80 (3.51-17.32) and 6.29 (2.11-18.73)]. Predictive factors for thromboembolic events included a previous history of thrombosis, pT4 stage, Gleason score ≥ 8 . ORP and LND had a higher risk of DVT and/or PE [RR 95%CI: 12.67 (5.05-31.77) versus 7.52 (2.84-19.88) in RARP]. In no-LND patients, ORP increased 3.8-fold the thromboembolic risk compared to RARP (95%CI 1.42-9.99). LND induced more wound, respiratory, cardiovascular and neuromusculoskeletal events. LND caused more re-admissions compared to no-LND (14.6% vs. 6.3%). CONCLUSIONS: Among other adverse events, we found that LND during radical prostatectomy increased the occurrence of DVT and PE. Open surgery increased the above risk more than robot-assisted surgery; this was most prominent in patients not undergoing LND.

Wallerstedt, A., et al. (2014). "Short-term Results after Robot-assisted Laparoscopic Radical Prostatectomy Compared to Open Radical Prostatectomy." European Urology.

BACKGROUND: Robot-assisted laparoscopic radical prostatectomy has become a widespread technique despite a lack of randomised trials showing its superiority over open radical prostatectomy. OBJECTIVE: To compare in-hospital characteristics and patient-reported outcomes at 3 mo between robot-assisted laparoscopic and open retropubic radical prostatectomy. DESIGN, SETTING, AND PARTICIPANTS: A prospective, controlled trial was performed of all men who underwent radical prostatectomy at 14 participating centres. Validated patient questionnaires were collected at baseline and after 3 mo by independent health-care researchers. OUTCOME MEASUREMENTS AND STATISTICAL ANALYSIS: The difference in outcome between the two treatment groups were analysed using logistic regression analysis, with adjustment for identified confounders. RESULTS AND LIMITATIONS: Questionnaires were received from 2506 (95%) patients. The robot-assisted surgery group had less perioperative bleeding (185 vs 683ml, $p < 0.001$) and shorter hospital stay (3.3 vs 4.1 d, $p < 0.001$) than the open surgery group. Operating time was shorter with the open technique (103 vs 175min, $p < 0.001$) compared with the robot-assisted technique. Reoperation during initial hospital stay was more frequent after open surgery after adjusting for tumour characteristics and lymph node dissection (1.6% vs 0.7%, odds ratio [OR] 0.31, 95% confidence interval [CI 95%] 0.11-0.90). Men who underwent open surgery were more likely to seek healthcare (for one or more of 22 specified disorders identified prestudy) compared to men in the robot-assisted surgery group ($p=0.03$). It was more common to seek healthcare for cardiovascular reasons in the open surgery group than in the robot-assisted surgery group, after adjusting for nontumour and tumour-specific confounders, (7.9% vs 5.8%, OR 0.63, CI 95% 0.42-0.94). The readmittance rate was not statistically different between the groups. A limitation of the study is the lack of a standardised tool for the assessment of the adverse events. CONCLUSIONS: This large prospective study confirms previous findings that robot-assisted laparoscopic radical prostatectomy is a safe procedure with some short-term advantages compared to open surgery. Whether these advantages also include long-term morbidity and are related to acceptable costs remain to be studied. PATIENT SUMMARY: We compare patient-reported outcomes between two commonly used surgical techniques. Our results show that the choice of surgical technique may influence short-term outcomes.

Willis, D. L. G., M. L.; Brotzman, M.; Feng, Z.; Trock, B.; Su, L. M. (2011). "Comparison of outcomes between pure laparoscopic vs robot-assisted laparoscopic radical prostatectomy: a study of comparative effectiveness based upon validated quality of life outcomes." BJU International.

This single surgeon study utilizes data from the EPIC questionnaire that was collected prospectively to compare urinary and sexual function after prostatectomy. In this comparison, return of post-prostatectomy continence was similar between groups while RALP patients demonstrated earlier return of sexual function. OBJECTIVE: * To compare perioperative, oncological and functional outcomes of laparoscopic radical prostatectomy (LRP) and robot-assisted laparoscopic radical prostatectomy (RALP) with emphasis on health-related quality of life (HRQOL) data as few studies exist. PATIENTS AND METHODS: * Patients underwent RALP or LRP by a single, fellowship trained surgeon with a standard clinical care pathway. * HRQOL data using the Expanded Prostate Cancer Index Composite (EPIC) were collected at 0, 3, 6 and 12 months after 175 consecutive LRP and 174 RALP procedures. * Urinary and sexual function outcomes were compared using two methods: (1) EPIC summary/subscale analyses described as percent return to baseline function and (2) traditional single-question analysis. RESULTS: * The two groups were statistically similar with respect to demographics, clinical stage, perioperative outcomes, stage-specific surgical margin rates, and baseline urinary and sexual function scores. * There was no statistical difference in postoperative urinary function between RALP and LRP using EPIC or single-question analyses at 3, 6 and 12 months. * EPIC questionnaire data showed a greater return to baseline sexual function over time (mixed model analysis) in RALP than in LRP patients who had a bilateral nerve sparing procedure (Sexual Summary Score, $P = 0.005$; Sexual Function and Bother Subscales, $P = 0.007$). * Using EPIC, RALP patients receiving a bilateral nerve sparing procedure showed improved percent return to baseline potency at 3 and 6 months ($P < 0.025$) compared with LRP patients, but had similar outcomes at 12 months (73.7% vs 66.2%, $P = 0.3$). * Single-question analysis suggested improved potency after RALP compared with LRP, with a greater percentage of RALP patients reporting successful sexual intercourse in the past 4 weeks (87.5% vs 66.7% at 12 months, $P = 0.06$). CONCLUSIONS: * When comparing surgical techniques, RALP and LRP groups showed statistically similar postoperative urinary function outcomes. * RALP patients had an earlier return of sexual function when compared with LRP patients after a bilateral nerve sparing procedure.

Large Real World retrospective Database Analysis (8)

Davis, J., et al. (2013). "Learning Curve Assessment of Robot-Assisted Radical Prostatectomy Compared to Open Surgery Controls from the Premier Perspective Database." Journal of Endourology.

Introduction: The primary aims of this study were to assess the learning curve effect of robot-assisted radical prostatectomy (RARP) in a large administrative database consisting of multiple U.S. hospitals and surgeons, and to compare the results of RARP to open radical prostatectomy (ORP) from the same settings. Materials and Methods: The patient population of study was from the Premier Perspective Database (Premier, Inc., Charlotte, NC) and consisted of 71,312 radical prostatectomies performed at more than 300 U.S. hospitals by up to 3,739 surgeons by open or robotic techniques from 2004-2010. The key endpoints were surgery time, inpatient length of stay, overall complications. We compared open versus robotic, results by year of procedures, results by case volume of specific surgeons, and results of open surgery in hospitals with and without a robotic system Results: The mean surgery time was longer for RARP (4.4 hours, SD 1.7) compared to ORP (3.4 hours, SD 1.5) in the same hospitals, $p < 0.0001$. Inpatient stay was shorter for RARP (2.2 days, SD 1.9) compared to ORP (3.2 days, SD 2.7) in the same hospitals, $p < 0.0001$. The overall complications were less for RARP (10.6%) compared to ORP (15.8%) in the same hospitals, as were transfusion rates. ORP results in hospitals without a robot were not better than ORP with a robot, and pre-treatment co-morbidity profiles were similar in all cohorts. Trending of results by year of procedure showed no differences in the 3 cohorts, but trending of RARP results by surgeon experience showed improvements in surgery time, hospital stay, conversion rates, and complication rates. Conclusions: During the initial seven years of RARP development, outcomes showed decreased hospital stay, complications, and transfusion rates. Learning curve trends for RARP were evident for these endpoints when grouped by surgeon experience, but not by year of surgery.

Gandaglia, G., et al. (2014). "The impact of robot-assisted radical prostatectomy on the use and extent of pelvic lymph node dissection in the "post-dissemination" period." European Journal of Surgical Oncology.

INTRODUCTION: Previous series during the dissemination era of minimally invasive techniques for treatment of prostate cancer (PCa) showed a declining use of pelvic lymph node dissection (PLND). The aim of our study was to re-assess the impact of robot-assisted radical prostatectomy (RARP) on the utilization rate of PLND and its extent in the post-dissemination period. METHODS: Relying on the Surveillance Epidemiology and End Results (SEER) Medicare-linked database, 5804 patients with non-metastatic PCa undergoing open radical prostatectomy (ORP) or RARP between years 2008 and 2009 were identified. Uni- and multivariable logistic regression analyses tested the relationship between surgical approach (RARP vs. ORP) and: 1 - the rate of PLND (pNx vs. pN0-1); and 2 - the extent of PLND (limited vs. extended). RESULTS: Overall, 3357 (57.8%) patients underwent a PLND. The proportion of patients treated with PLND was significantly higher among ORP vs. RARP patients: 71.2 vs. 48.6%, respectively ($P < 0.001$). In addition, the median number of lymph nodes removed was significantly higher for patients treated with ORP vs. RARP: 5 vs. 4, respectively ($P < 0.001$). In multivariable analyses, ORP was associated with 2.7- and 1.3-fold higher odds of undergoing PLND and of receiving an extended PLND compared to RARP, respectively (both $P \leq 0.001$). Stratified analyses according to disease risk classifications revealed similar trends. CONCLUSIONS: In the post-dissemination era, RARP remains associated with a decreased use of PLND and suboptimum extent. Efforts should be made to improve guideline adherence in performing a PLND whenever indicated according to tumor aggressiveness, despite surgical approach.

Friethriksson, J. O., et al. (2014). "Readmission after Radical Prostatectomy in a Nationwide, Population-based Study." Journal of Urology.

PURPOSE: To investigate readmission frequencies during the 90 days following radical prostatectomy and to assess readmission risk associated with potentially related variables. MATERIALS AND METHODS: Using the population-based, nationwide database Prostate Cancer data Base Sweden (PCBaSe), we identified men diagnosed with incident prostate cancer between 2000 and 2011 who underwent radical prostatectomy (RP) as their primary treatment, and we used logistic regression analysis to examine the association of the risk of 90-day postoperative readmission with surgical method, calendar period, tumor risk category, hospital case load, and patient characteristics. RESULTS: During the 90 postoperative days, 2,317 (10%) of the 24,122 men identified were non-electively readmitted, specifically 10% after retropubic radical prostatectomy (RRP), 9% after robot-assisted RP (RALP) and 11% after laparoscopic RP (LRP). The range in the readmission frequency between hospitals was 0-35%. A higher risk of readmission was associated with early calendar period (2009-2011 vs. 2000-2002: odds ratio (OR), 0.71; 95% confidence interval (CI), 0.61-0.83), greater age (≥ 70 years vs. < 60 years: OR, 1.17; 95% CI, 1.00-1.36), higher risk category (high vs. low-risk category: OR, 1.78; 95% CI, 1.57-2.03), high comorbidity (Charlson comorbidity index ≥ 3 vs. 0: OR, 1.77; 95% CI, 1.29-2.44), and low hospital surgical volume (≥ 150 vs. < 30 RPs per year: OR, 0.70; 95% CI, 0.60-0.81). CONCLUSIONS: Readmission rates after different RP methods were similar, ranging from 9% to 11%, with a wide variation between hospitals. Readmission rates can be used as an indicator of perioperative care quality, but potential confounders need to be adjusted to avoid bias.

Hu, J. C., et al. (2014). "Comparative Effectiveness of Robot-assisted Versus Open Radical Prostatectomy Cancer Control." European Urology.

Background: Robot-assisted radical prostatectomy (RARP) remains controversial, and no improvement in cancer control outcomes has been demonstrated over open radical prostatectomy (ORP). Objective: To examine population-based, comparative effectiveness of

RARP versus ORP surgical margin status and use of additional cancer therapy. Design, setting, and participants: This was a retrospective observational study of 5556 RARP and 7878 ORP cases from 2004 to 2009 from Surveillance Epidemiology and End Results Medicare linked data. Intervention: RARP versus ORP. Outcome measurements and statistical analysis: Propensity-based analyses were performed to minimize treatment selection biases. Generalized linear regression models were computed for comparison of RP surgical margin status and use of additional cancer therapy (radiation therapy [RT] or androgen deprivation therapy [ADT]) by surgical approach.

Results and limitations: In the propensity-adjusted analysis, RARP was associated with fewer positive surgical margins (13.6% vs 18.3%; odds ratio [OR]: 0.70; 95% confidence interval [CI], 0.66–0.75), largely because of fewer RARP positive margins for intermediate risk (15.0% vs 21.0%; OR: 0.66; 95% CI, 0.59–0.75) and high-risk (15.1% vs 20.6%; OR: 0.70; 95% CI, 0.63–0.77) disease. In addition, RARP was associated with less use of additional cancer therapy within 6 mo (4.5% vs 6.2%; OR: 0.75; 95% CI, 0.69–0.81), 12 mo (OR: 0.73; 95% CI, 0.62–0.86), and 24 mo (OR: 0.67; 95% CI, 0.57–0.78) of surgery. Limitations include the retrospective nature of the study and the absence of prostate-specific antigen levels to determine biochemical recurrence.

Conclusions: RARP is associated with improved surgical margin status relative to ORP for intermediate- and high-risk disease and less use of postprostatectomy ADT and RT. This has important implications for quality of life, health care delivery, and costs. Patient summary: Robot-assisted radical prostatectomy (RP) versus open RP is associated with fewer positive margins and better early cancer control because of less use of additional androgen deprivation and radiation therapy within 2 yr of surgery.

Kim, S. P. S., N. D.; Karnes, R. J.; Weight, C. J.; Shippee, N. D.; Han, L. C.; Boorjian, S. A.; Smaldone, M. C.; Frank, I.; Gettman, M. T.; Tollefson, M. K.; Thompson, R. H. (2012). "Hospitalization Costs for Radical Prostatectomy Attributable to Robotic Surgery." European Urology.

Background: With health technology innovation responsible for higher health care costs, it is essential to have accurate estimates regarding the differential costs between robot-assisted radical prostatectomy (RARP) and open radical prostatectomy (ORP). Objective: To describe the total hospitalization costs attributable to robotic and open surgery for radical prostatectomy (RP). Design, setting, and participants: Using a population-based cohort by merging the Nationwide Inpatient Sample (NIS) and the American Hospital Association (AHA) survey from 2006 to 2008, we identified 29 837 prostate cancer patients who underwent RP. Interventions: ORP and RARP. Outcome measurements and statistical analysis: The primary outcome was total hospitalization costs adjusted to year 2008 US dollars. Generalized estimating equations were used to identify patient and hospital characteristics associated with total hospitalization costs and to estimate costs of ORP and RARP adjusted for case mix and hospital teaching status, location, and annual case volume. Results and limitations: Overall, 20 424 (68.5%) patients were surgically treated with RARP, and 9413 (31.5%) patients underwent ORP. Compared to ORP, patients undergoing RARP had shorter median length of stay (1 d vs 2 d; $p < 0.001$) and were less likely to experience any postoperative complications (8.2% vs 11.3%; $p < 0.001$). However, patients undergoing RARP had higher median hospitalization costs (\$10 409 vs \$8862; $p < 0.001$). After adjusting for patient and hospital features, RARP was associated with higher total hospitalization costs compared to ORP (\$11 932 vs \$9390; $p < 0.001$). Our results are limited by a study design using retrospective population-based data. Conclusions: Despite RARP having lower complications and shorter length of stay than ORP, total hospitalization costs are higher for patients treated with RARP compared with those treated with ORP. © 2012 European Association of Urology.

Pilecki, M. A., et al. (2013). "National multi-institutional comparison of 30-day post-operative complication and re-admission rates between open retropubic radical prostatectomy (RRP) and robot-assisted laparoscopic prostatectomy (RALRP) using NSQIP." Journal of Endourology.

Background: Many American hospitals will soon face readmissions penalties deducted from Medicare reimbursements, which will place further scrutiny on techniques which may offer reduced post-operative morbidity. We aimed to perform the first multi-institutional study using the National Surgical Quality Improvement Program (NSQIP) database, to compare predictors of readmission within cohorts of open Radical Retropubic Prostatectomy (RRP) and Robotic Assisted Laparoscopic Radical Prostatectomy (RALRP) in a contemporary nationwide series of radical prostatectomy. Methods: All patients undergoing radical prostatectomy in 2011 were identified in the National NSQIP database using procedural codes. As no patients in the analysis underwent laparoscopic radical prostatectomy (LRP) patients were grouped as RRP or RALRP for analysis. Peri-operative variables were analyzed using Chi-squared and Student's T-test as appropriate. Multiple logistic regression was used to identify readmission risk factors. Results: Of 5,471 patient cases analyzed, 4374 (79.9%) and 1097 (20.1%) underwent RALRP and RRP, respectively. RRP and RALRP cohorts experienced different re-admission rates (5.47% vs. 3.48%, respectively; $p = 0.002$). In addition, RRP experienced a higher rate of overall complications than RALRP (23.25% vs. 5.62%, respectively; $p < 0.001$), but not higher rates of reoperation (1.09% vs. 0.96%, respectively; $p = 0.689$). Overall predictors of re-admission included operative time, dyspnea, and RRP or RALRP procedure type. Current smoking and patient age were predictive of readmission for RRP only, while dyspnea was predictive of readmission following RALRP only. Conclusion: This is the first multi-institutional retrospective study examining readmission rates and procedural intracohort predictors of readmission for RRP in the contemporary United States. We report a significant difference in post-operative complication and readmission rates in RRP compared to RALRP. Further prospective analysis is warranted.

Sammon, J. D. K., P. I.; Sun, M.; Sukumar, S.; Ravi, P.; Ghani, K. R.; Bianchi, M.; Peabody, J. O.; Shariat, S. F.; Perrotte, P.; Hu, J. C.; Menon, M.; Trinh, Q. D. (2012). "Robot-assisted vs. Open radical prostatectomy: The differential effect of regionalization, procedure volume and operative approach." Journal of Urology.

BACKGROUND: Utilization of robot-assisted radical prostatectomy (RARP) has increased rapidly, despite the absence of randomized controlled trials demonstrating the superiority of this approach. While recent studies suggest an advantage in perioperative complication rates, they fail to account for the volume-outcome relationship. We sought to compare perioperative outcomes after RARP vs. ORP, whilst fully considering the impact of this established relationship. METHODS: Using the Nationwide Inpatient Sample, patients undergoing RP in 2009 were abstracted. Univariable and multivariable logistic regression analyses compared rates of blood transfusions, intraoperative and postoperative complications, prolonged length of stay (pLOS), elevated hospital charges (EHC), and mortality between RARP and ORP, overall and across volume quartiles. RESULTS: An estimated 77616 men underwent RP (RARP: 63.9%, ORP: 36.1%). Low-volume centers averaged 26.2 (RARP) and 5.2 (ORP) cases, very high-volume centers averaged 578.8 (RARP) and 150.2 (ORP) cases. Overall, RARP-treated patients experienced lower rates of adverse outcomes than ORP patients, in all measured categories. Across equivalent volume quartiles, RARP outcomes were generally favorable; however ORP at very high-volume centers produced lower rates of postoperative complications (OR: 0.59 (95%CI: 0.46-0.75)), EHC (0.75 (0.64-0.87)) and comparable rates of blood transfusions (1.38 (0.93-2.02)) relative to RARP at low-volume centers. CONCLUSION: Regionalization has occurred to a greater extent for RARP than ORP, with an associated benefit in overall outcomes. Nonetheless, low volume institutions experienced inferior outcomes relative to the highest volume centers irrespective of approach. These findings demonstrate the importance of accounting for hospital volume when examining the benefit of a surgical technique.

Trinh, Q. D., et al. (2012). "Perioperative Outcomes of Robot-Assisted Prostatectomy Compared With Open Radical Prostatectomy: Results From the Nationwide Inpatient Sample." *European Urology* 61(4): 679-685.

Background: Prior to the introduction and dissemination of robot-assisted radical prostatectomy (RARP), population-based studies comparing open radical prostatectomy (ORP) and minimally invasive radical prostatectomy (MIRP) found no clinically significant difference in perioperative complication rates. Objective: Assess the rate of RARP utilization and reexamine the difference in perioperative complication rates between RARP and ORP in light of RARP's supplanting laparoscopic radical prostatectomy (LRP) as the most common MIRP technique. Design, setting, and participants: As of October 2008, a robot-assisted modifier was introduced to denote robot-assisted procedures. Relying on the Nationwide Inpatient Sample between October 2008 and December 2009, patients treated with radical prostatectomy (RP) were identified. The robot-assisted modifier (17.4x) was used to identify RARP (n = 11 889). Patients with the minimally invasive modifier code (54.21) without the robot-assisted modifier were classified as having undergone LRP and were removed from further analyses. The remainder were classified as ORP patients (n = 7389). Intervention: All patients underwent RARP or ORP. Measurements: We compared the rates of blood transfusions, intraoperative and postoperative complications, prolonged length of stay (pLOS), and in-hospital mortality. Multivariable logistic regression analyses of propensity score-matched populations, fitted with general estimation equations for clustering among hospitals, further adjusted for confounding factors. Results and limitations: Of 19 462 RPs, 61.1% were RARPs, 38.0% were ORPs, and 0.9% were LRPs. In multivariable analyses of propensity score-matched populations, patients undergoing RARP were less likely to receive a blood transfusion (odds ratio [OR]: 0.34; 95% confidence interval [CI], 0.28-0.40), to experience an intraoperative complication (OR: 0.47; 95% CI, 0.31-0.71) or a postoperative complication (OR: 0.86; 95% CI, 0.77-0.96), and to experience a pLOS (OR: 0.28; 95% CI, 0.26-0.30). Limitations of this study include lack of adjustment for tumor characteristics, surgeon volume, learning curve effect, and longitudinal follow-up. Conclusions: RARP has supplanted ORP as the most common surgical approach for RP. Moreover, we demonstrate superior adjusted perioperative outcomes after RARP in virtually all examined outcomes. © 2011 European Association of Urology.

Adrenalectomy (with abstract)

- Comprehensive literature search Open Adrenalectomy versus Robotic Adrenalectomy versus Conventional Laparoscopic Adrenalectomy – 2010 to 2015
- Study types included: RCTs, prospective comparative studies, systematic reviews and/or meta-analysis, large (>5000 patients) real world retrospective database studies of established and high quality databases: PREMIERE, SEERS, NSQIP, NIS. HTAs
- This is a comprehensive literature search according to the above mentioned inclusion criteria. The search has been done with rigor, but we make no claim of being complete.

Systematic Review and/or Meta-Analysis (3)

Brandao, L. F., et al. (2013). "Robotic Versus Laparoscopic Adrenalectomy: A Systematic Review and Meta-analysis." European Urology.

CONTEXT: Over the last decade, robot-assisted adrenalectomy has been included in the surgical armamentarium for the management of adrenal masses. OBJECTIVE: To critically analyze the available evidence of studies comparing laparoscopic and robotic adrenalectomy. EVIDENCE ACQUISITION: A systematic literature review was performed in August 2013 using PubMed, Scopus, and Web of Science electronic search engines. Article selection proceeded according to the search strategy based on Preferred Reporting Items for Systematic Reviews and Meta-analysis criteria. EVIDENCE SYNTHESIS: Nine studies were selected for the analysis including 600 patients who underwent minimally invasive adrenalectomy (277 robot assisted and 323 laparoscopic). Only one of the studies was a randomized clinical trial (RCT) but of low quality according to the Jadad scale. However, the methodological quality of included nonrandomized studies was relatively high. Body mass index was higher for the laparoscopic group (weighted mean difference [WMD]: -2.37; 95% confidence interval [CI], - 3.01 to -1.74; $p < 0.00001$). A transperitoneal approach was mostly used for both techniques (72.5% of robotic cases and 75.5% of laparoscopic cases; $p = 0.27$). There was no significant difference between the two groups in terms of conversion rate (odds ratio [OR]: 0.82; 95% CI, 0.39-1.75; $p = 0.61$) and operative time (WMD: 5.88; 95% CI, -6.02 to 17.79; $p = 0.33$). There was a significantly longer hospital stay in the conventional laparoscopic group (WMD: -0.43; 95% CI, -0.56 to -0.30; $p < 0.00001$), as well as a higher estimated blood loss (WMD: -18.21; 95% CI, -29.11 to -7.32; $p = 0.001$). There was also no statistically significant difference in terms of postoperative complication rate (OR: 0.04; 95% CI, -0.07 to -0.00; $p = 0.05$) between groups. Most of the postoperative complications were minor (80% for the robotic group and 68% for the conventional laparoscopic group). Limitations of the present analysis are the limited sample size and including only one low-quality RCT. CONCLUSIONS: Robot-assisted adrenalectomy can be performed safely and effectively with operative time and conversion rates similar to laparoscopic adrenalectomy. In addition, it can provide potential advantages of a shorter hospital stay, less blood loss, and lower occurrence of postoperative complications. These findings seem to support the use of robotics for the minimally invasive surgical management of adrenal masses.

Chai, Y. J., et al. (2014). "Systematic Review of Surgical Approaches for Adrenal Tumors: Lateral Transperitoneal versus Posterior Retroperitoneal and Laparoscopic versus Robotic Adrenalectomy." Int J Endocrinol **2014**: 918346.

Background. Laparoscopic lateral transperitoneal adrenalectomy (LTA) has been the standard method for resecting benign adrenal gland tumors. Recently, however, laparoscopic posterior

retroperitoneal adrenalectomy (PRA) has been more popular as an alternative method. This systematic review evaluates current evidence on adrenalectomy techniques, comparing laparoscopic LTA with PRA and laparoscopic adrenalectomy with robotic adrenalectomy. Methods. PubMed, Embase, and ISI Web of Knowledge databases were searched systematically for studies comparing surgical outcomes of laparoscopic LTA versus PRA and laparoscopic versus robotic adrenalectomy. The studies were evaluated according to the PRISMA statement. Results. Eight studies comparing laparoscopic PRA and LTA showed that laparoscopic PRA was superior or at least comparable to laparoscopic LTA in operation time, blood loss, pain score, hospital stay, and return to normal activity. Conversion rates and complication rates were similar. Six studies comparing robotic and laparoscopic adrenalectomy found that outcomes and complications were similar. Conclusion. Laparoscopic PRA was more effective than LTA, especially in reducing operation time and hospital stay, but there was no evidence showing that robotic adrenalectomy was superior to laparoscopic adrenalectomy. Cost reductions and further technical advances are needed for wider application of robotic adrenalectomy.

Tang, K., et al. (2015). "Robot-Assisted Versus Laparoscopic Adrenalectomy: A Systematic Review and Meta-analysis." *Journal of Laparoendoscopic and Advanced Surgical Techniques, Part A* **25**(3): 187-195.

BACKGROUND: More recently, robot-assisted adrenalectomy (RA) has emerged as an attractive alternative to laparoscopic adrenalectomy (LA), and many studies have shown the feasibility and safety of RA. However, the short- and long-term outcomes of RA versus LA have not been adequately assessed, and the advantage over the laparoscopic approach has not been demonstrated. The aim of this study was to compare the outcomes of RA versus LA by means of a systematic review and meta-analysis of the available literature in the early experience. MATERIALS AND METHODS: A systematic search of PubMed, SCI/SSCI, CNKI, and the Cochrane Library was performed to identify prospective randomized controlled trials and retrospective observational studies that compared RA and LA and were published between January 2006 to the end of December 2012. Outcomes of interest included demographic and clinical characteristics, perioperative variables, and complications. The meta-analysis was prepared in accordance with the Quality of Reporting of Meta-analyses (QUOROM) statement. RESULTS: Eight trials (232 cases and 297 controls) assessing RA versus LA were considered suitable for meta-analysis, including six prospective and two retrospective studies. There was a significant trend to choose patients for the performance of RA who were associated with a lower body mass index (weighted mean difference [WMD]=-2.78 kg/m²; 95% confidence interval [CI], -3.00 to -2.55; P<.001) and higher incidence of previous surgery (odds ratio=1.59; 95% CI, 0.99-2.54; P=.05). There were no significant differences between the two groups in any other of the demographic parameters. With regard to perioperative variables, although there was a significant difference in the operating time in favor of LA (WMD=17.52 minutes; 95% CI, 3.48-31.56; P=.01), patients having RA might benefit from significantly less blood loss (WMD=-19.00 mL; 95% CI, -34.58 to -3.41; P=.02) and shorter length of hospital stay (WMD=-0.35 day; 95% CI, -0.51 to -0.19; P<.001). There were no significant differences between RA and LA with regard to conversion rates and overall complications. Sensitivity analysis performed by two methods both showed a positive reversal in the operating time with the statistical significance removed compared with the original analysis. CONCLUSIONS: In the early experience, our data suggest that RA, compared with LA, may be a safe and feasible option associated with less blood loss and shorter hospital stay when performed by experienced surgeons in selected patients.

Prospective comparative studies (2)

Agcaoglu, O., et al. (2012). "Robotic vs Laparoscopic Posterior Retroperitoneal Adrenalectomy." *Archives of Surgery* **147**(3): 272-275.

OBJECTIVE: To compare robotic vs laparoscopic posterior retroperitoneal adrenalectomy with regard to perioperative outcomes. DESIGN: Prospectively study. SETTING: Tertiary academic center. PATIENTS: Thirty-one patients who underwent robotic posterior retroperitoneal

adrenalectomy and 31 consecutive patients who underwent laparoscopic posterior retroperitoneal adrenalectomy from a prospective institutional review board-approved database. MAIN OUTCOME MEASURES: Demographic and clinical parameters, operative time, presence of complications, length of hospital stay, and pain score on postoperative days 1 and 14. RESULTS: The mean (SEM) tumor sizes for the robotic and laparoscopic groups were similar (3.1 [0.2] and 3.0 [0.2] cm, respectively; $P = .48$). For all patients, the mean (SEM) skin-to-skin operative times were similar in both groups (163.2 [10.1] and 165.7 [9.5] minutes, respectively; $P = .43$). When the last 21 patients who underwent robotic posterior retroperitoneal adrenalectomy were compared with the 31 patients from the laparoscopic series, it was seen that the mean (SEM) operative time was shorter for the robotic group than for the laparoscopic group (139.1 [10.9] vs 166.9 [8.2] minutes; $P = .046$). The mean (SEM) estimated blood losses and hospital stays were similar between groups. The mean (SEM) pain score on postoperative day 1 was lower in the robotic group than in the laparoscopic group (2.5 [0.3] vs 4.2 [0.4]; $P = .008$); however, the mean (SEM) pain scores for the groups were similar on postoperative day 14 ($P = .53$). There were no deaths or cases of morbidity in either group. CONCLUSIONS: Our study shows that, beyond the learning curve for experienced laparoscopic surgeons, robotic posterior retroperitoneal adrenalectomy shortens the skin-to-skin operative time compared with the laparoscopic approach. Our results also suggest that the immediate postoperative pain may be less severe for patients who undergo robotic posterior retroperitoneal adrenalectomy.

Agcaoglu, O. A., S.; Karabulut, K.; Mitchell, J.; Siperstein, A.; Berber, E. (2012). "Robotic Versus Laparoscopic Resection of Large Adrenal Tumors." *Annals of Surgical Oncology*: 1-7.

Background: Although recent studies have shown the feasibility and safety of robotic adrenalectomy, an advantage over the laparoscopic approach has not been demonstrated. Our hypothesis was that the use of the robot would facilitate minimally invasive resection of large adrenal tumors. Methods: Adrenal tumors ≥ 5 cm resected robotically were compared with those removed laparoscopically from a prospective institutional review board-approved adrenal database. Clinical and perioperative parameters were analyzed using t and chi-square tests. All data are expressed as mean \pm standard error of mean. Results: There were 24 patients with 25 tumors in the robotic group and 38 patients with 38 tumors in the laparoscopic group. Tumor size was similar in both groups (6.5 \pm 0.4 [robotic] vs 6.2 \pm 0.3 cm [laparoscopic], $P = .661$). Operative time was shorter for the robotic versus laparoscopic group (159.4 \pm 13.4 vs 187.2 \pm 8.3 min, respectively, $P = .043$), while estimated blood loss was similar ($P = .147$). The conversion to open rate was less in the robotic (4%) versus the laparoscopic (11%) group; $P = .043$. Hospital stay was shorter for the robotic group (1.4 \pm 0.2 vs 1.9 \pm 0.1 days, respectively, $P = .009$). The 30-day morbidity was 0 in robotic and 2.7% in laparoscopic group. Pathology was similar between groups. Conclusions: Our study shows that the use of the robot could shorten operative time and decrease the rate of conversion to open for adrenal tumors larger than 5 cm. Based on our favorable experience, robotic adrenalectomy has become our preferred minimally invasive surgical approach for removing large adrenal tumors. © 2012 Society of Surgical Oncology.

Cystectomy (with abstract)

- Comprehensive literature search Open cystectomies versus Robotic assisted cystectomies versus Conventional laparoscopic cystectomies – 2010 to 2015
- Study types included: RCTs, prospective comparative studies, systematic reviews with meta-analysis, large (>5000 patients) real world retrospective database studies of established and high quality databases: PREMIERE, SEERS, NSQIP, NIS. HTAs
- This is a comprehensive literature search according to the above mentioned criteria. The search has been done with rigor, but we make no claim of being complete.

Randomized Controlled Trials (2)

Bochner, B. H., et al. (2014). "Comparing Open Radical Cystectomy and Robot-assisted Laparoscopic Radical Cystectomy: A Randomized Clinical Trial." *European Urology*.

BACKGROUND: Open radical cystectomy (ORC) and urinary diversion in patients with bladder cancer (BCa) are associated with significant perioperative complication risk. **OBJECTIVE:** To compare perioperative complications between robot-assisted radical cystectomy (RARC) and ORC techniques. **DESIGN, SETTING, AND PARTICIPANTS:** A prospective randomized controlled trial was conducted during 2010 and 2013 in BCa patients scheduled for definitive treatment by radical cystectomy (RC), pelvic lymph node dissection (PLND), and urinary diversion. Patients were randomized to ORC/PLND or RARC/PLND, both with open urinary diversion. Patients were followed for 90 d postoperatively. **INTERVENTION:** Standard ORC or RARC with PLND; all urinary diversions were performed via an open approach. **OUTCOME MEASUREMENTS AND STATISTICAL ANALYSIS:** Primary outcomes were overall 90-d grade 2-5 complications defined by a modified Clavien system. Secondary outcomes included comparison of high-grade complications, estimated blood loss, operative time, pathologic outcomes, 3- and 6-mo patient-reported quality-of-life (QOL) outcomes, and total operative room and inpatient costs. Differences in binary outcomes were assessed with the chi-square test, with differences in continuous outcomes assessed by analysis of covariance with randomization group as covariate and, for QOL end points, baseline score. **RESULTS AND LIMITATIONS:** The trial enrolled 124 patients, of whom 118 were randomized and underwent RC/PLND. Sixty were randomized to RARC and 58 to ORC. At 90 d, grade 2-5 complications were observed in 62% and 66% of RARC and ORC patients, respectively (95% confidence interval for difference, -21% to -13%; $p=0.7$). The similar rates of grade 2-5 complications at our mandated interim analysis met futility criteria; thus, early closure of the trial occurred. The RARC group had lower mean intraoperative blood loss ($p=0.027$) but significantly longer operative time than the ORC group ($p<0.001$). Pathologic variables including positive surgical margins and lymph node yields were similar. Mean hospital stay was 8 d in both arms (standard deviation, 3 and 5 d, respectively; $p=0.5$). Three- and 6-mo QOL outcomes were similar between arms. Cost analysis demonstrated an advantage to ORC compared with RARC. A limitation is the setting at a single high-volume, referral center; our findings may not be generalizable to all settings. **CONCLUSIONS:** This trial failed to identify a large advantage for robot-assisted techniques over standard open surgery for patients undergoing RC/PLND and urinary diversion. Similar 90-d complication rates, hospital stay, pathologic outcomes, and 3- and 6-mo QOL outcomes were observed regardless of surgical technique. **PATIENT SUMMARY:** Of 118 patients with bladder cancer who underwent radical cystectomy, pelvic lymph node dissection, and urinary diversion, half were randomized to open surgery and half to robot-assisted laparoscopic surgery. We compared the rate of complications within 90 d after surgery for the open group versus the robotic group and found no significant difference between the two groups. **TRIAL REGISTRATION:** ClinicalTrials.gov identifier NCT01076387, www.clinicaltrials.gov.

Messer, J. C., et al. (2014). "Health Related Quality of Life From A Prospective Randomized Clinical Trial of Robotic Assisted Laparoscopic Versus Open Radical Cystectomy." *BJU International* **114**(6): 896-902.

OBJECTIVE: Robotic Assisted Laparoscopic Radical Cystectomy (RARC) has been reported with potential benefits compared to the traditional Open Radical Cystectomy (ORC), though to date no study has compared health related quality of life (HRQOL) outcomes between ORC and RARC in a prospective randomized fashion. PATIENTS AND METHODS: Prospective Randomized Clinical trial evaluating the HRQOL for ORC versus RARC in consecutive patients from July 2009 to June 2011. We administered the FACT-VCI HRQOL preoperatively and then at 3, 6, 9, and 12 months postoperatively. Scores for each domain and total score were compared for deviation from preoperative values for both the robotic and the open cohort. Multivariate linear regression assessed the association between procedure approach and HRQOL. RESULTS: To date 47 patients had met inclusion criteria, with 40 patients being randomized for analysis. The groups consisted of 20 ORC and 20 RARC patients who were balanced with respect to baseline demographic and clinical features. Univariate Analysis noted a return to baseline at 3 months postoperatively in all measured domains with no statistically significant difference among the various domains between the robotic and open groups. Multivariate Analysis showed no difference in HRQOL between the two approaches in all the various domains, with the exception of a slightly higher physical well being score in the robotic group at 6 months. CONCLUSIONS: There are no significant differences in the HRQOL outcomes between ORC and RARC with return of quality of life to baseline 3 months after radical cystectomy in both the open and robotic cohort.

Systematic Review and/or Meta-Analysis (8)

Fonseka, T., et al. (2015). "Comparing robotic, laparoscopic and open cystectomy: a systematic review and meta-analysis." *Archivio Italiano di Urologia, Andrologia* **87**(1): 41-48.

OBJECTIVE: To conduct a systematic review and meta-analysis comparing outcomes between Open Radical Cystectomy (ORC), Laparoscopic Radical Cystectomy (LRC) and Robot-assisted Radical Cystectomy (RARC). RARC is to be compared to LRC and ORC and LRC compared to ORC. MATERIAL AND METHODS: A systematic review of the literature was conducted, collating studies comparing RARC, LRC and ORC. Surgical and oncological outcome data were extracted and a meta-analysis was performed. RESULTS: Twenty-four studies were selected with total of 2,104 cases analyzed. RARC had a longer operative time (OPT) compared to LRC with no statistical difference between length of stay (LOS) and estimated blood loss (EBL). RARC had a significantly shorter LOS, reduced EBL, lower complication rate and longer OPT compared to ORC. There were no significant differences regarding lymph node yield (LNY) and positive surgical margins (PSM.) LRC had a reduced EBL, shorter LOS and increased OPT compared to ORC. There was no significant difference regarding LNY. CONCLUSION: RARC is comparable to LRC with better surgical results than ORC. LRC has better surgical outcomes than ORC. With the unique technological features of the robotic surgical system and increasing trend of intra-corporeal reconstruction it is likely that RARC will become the surgical option of choice.

Guiote, I., et al. (2015). "Complications from robot-assisted radical cystectomy: Where do we stand?" *Actas Urologicas Espanolas*.

INTRODUCTION: Radical cystectomy with extended lymphadenectomy is the surgical treatment of choice for muscle-invasive bladder cancer. The technical and technological improvements and the positive results from robot-assisted kidney and prostate surgery have led to the progressive development of robot-assisted radical cystectomy (RARC). We provide a global structured overview and an update on the complications of RARC, recorded according to the Clavien-Dindo classification system. ACQUISITION OF EVIDENCE: We conducted a search on PubMed of all publications on RARC to date (2014). Of the 259 publications found, we excluded review articles and cost analyses, publications with less than 30 cases, updates of previous studies and those whose main objective was the study of other issues related to RARC other than complications, leaving a total of 38 articles for the final analysis. SUMMARY OF THE EVIDENCE: The most

common complications associated with RARC are gastrointestinal, infectious and genitourinary system, mainly Clavien 1-2, followed by Clavien 3-4. RARC had lower overall complication rates than open radical cystectomy and laparoscopic radical cystectomy and had a lower incidence of severe complications, less intraoperative bleeding and better postoperative recovery.

CONCLUSIONS: Although further scientific evidence is needed, RARC is an increasingly widespread technique that appears to reduce complications as well as the need for transfusion, and it improves recovery times.

Ishii, H., et al. (2014). "Robotic or Open radical cystectomy, which is safer? A systematic review and Meta-analysis of comparative studies." Journal of Endourology **28**(10): 1215-1223.

Abstract To compare early surgical outcomes for robotic (RRC) and open (ORC) radical cystectomy with an emphasis on complications and postoperative mortality. Methods: Evidence acquisition: A literature review was conducted from 2000 to 2013 including studies comparing robotic and open radical cystectomy. The main outcome measures analysed were the complications and mortality, in addition to patient demographics, pathological parameters, operating time, estimated blood loss, transfusion rates, and type of urinary diversion. A meta-analysis was conducted. For continuous data, Mantel-Haenszel Chi-square test was used and for dichotomous data, Inverse Variance was used and each expressed as risk ratio with 95% CI. Results: In total 748 patients were included, 461 patients in the robotic group and 287 patients in the open group (7 studies). There were no significant differences in the demographic parameters of the two groups, except for age (Age: $P=0.03$). There was no difference in the number of muscle invasive disease: $P=0.47$. No difference in positive surgical margin rates ($P=0.21$). Primary Outcomes: The overall ($P=0.32$) and lower grade (Clavien I-II) ($P=0.10$) complication rates between the two cohorts didn't achieve statistical significance. The high-grade (Clavien III-IV) ($P=0.007$) complication rates in the ORC group were significantly higher. The mortality (Clavien V) was higher in ORC group (2.2%) compared with the RRC group (0.35%) and this did achieve statistical significance on a meta-analysis ($P=0.04$) Secondary Outcomes: The Estimated Blood loss and transfusion rates were statistically significantly lower in the RRC cohort ($P<0.00001$). The operating time is statistically significantly higher in the RRC cohort ($P<0.00001$). There was no statistical significant difference in the margin positivity between the two cohorts ($P=0.08$). Conclusion: Robotic Radical cystectomy appears to have lower high-grade complication and mortality compared to the open approach. Although these results are promising, the authors would suggest caution while interpreting these results due to concerns with methodological flaws in the included studies in this review.

Li, K., et al. (2013). "Systematic review and meta-analysis of comparative studies reporting early outcomes after robot-assisted radical cystectomy versus open radical cystectomy." Cancer Treatment Reviews **39**(6): 551-560.

Background: Robot-assisted radical cystectomy (RARC) is increasingly being used in the management of bladder cancer. Studies comparing RARC and open radical cystectomy (ORC) have reported conflicting results. We conducted a systematic review and meta-analysis of the literature on the efficacy and advantages of RARC compared with ORC. Methods: An electronic database search of PubMed, Scopus, and the Cochrane Library was performed up to July 8, 2012. This systematic review and meta-analysis was performed based on all randomized controlled trials (RCTs) and observational comparative studies assessing the two techniques. Results: One RCT, eight studies with prospectively collected data, and four retrospective studies were identified, including 962 cases. Although RARC was associated with longer operative time ($p<0.001$), patients in this group might benefit from less overall perioperative complications ($p=0.04$), more lymph node yield ($p=0.009$), less estimated blood loss ($p<0.001$), a lower need for perioperative transfusion ($p<0.001$), and shorter length of hospital stay ($p<0.001$). Positive surgical margins did not differ significantly between techniques. Sensitivity analysis with prospective studies showed similar results to the original analysis, but no significant difference of lymph node yield and length of stay between two techniques. Conclusions: RARC is a mini-

invasive alternative to ORC with less overall perioperative complications, more lymph node yields, less estimated blood loss, less need for a perioperative transfusion, and shorter length of stay.

Novara, G., et al. (2015). "Systematic Review and Cumulative Analysis of Perioperative Outcomes and Complications After Robot-assisted Radical Cystectomy." *European Urology* **67**(3): 376-401.

Context: Although open radical cystectomy (ORC) is still the standard approach, laparoscopic radical cystectomy (LRC) and robot-assisted radical cystectomy (RARC) have gained popularity. Objective: To report a systematic literature review and cumulative analysis of perioperative outcomes and complications of RARC in comparison with ORC and LRC. Evidence acquisition: Medline, Scopus, and Web of Science databases were searched using a free-text protocol including the terms robot-assisted radical cystectomy or da Vinci radical cystectomy or robot* radical cystectomy. RARC case series and studies comparing RARC with either ORC or LRC were collected. Cumulative analysis was conducted. Evidence synthesis: The searches retrieved 105 papers. According to the different diversion type, overall mean operative time ranged from 360 to 420. min. Similarly, mean blood loss ranged from 260 to 480. ml. Mean in-hospital stay was about 9 d for all diversion types, with consistently high readmission rates. In series reporting on RARC with either extracorporeal or intracorporeal conduit diversion, overall 90-d complication rates were 59% (high-grade complication: 15%). In series reporting RARC with intracorporeal continent diversion, the overall 30-d complication rate was 45.7% (high-grade complication: 28%). Reported mortality rates were $\leq 3\%$ for all diversion types. Comparing RARC and ORC, cumulative analyses demonstrated shorter operative time for ORC, whereas blood loss and in-hospital stay were better with RARC (all p values < 0.003). Moreover, 90-d complication rates of any-grade and 90-d grade 3 complication rates were lower for RARC (all p values < 0.04), whereas high-grade complication and mortality rates were similar. Conclusions: RARC can be performed safely with acceptable perioperative outcome, although complications are common. Cumulative analyses demonstrated that operative time was shorter with ORC, whereas RARC may provide some advantages in terms of blood loss and transfusion rates and, more limitedly, for postoperative complication rates over ORC and LRC. Patient summary: Although open radical cystectomy (RC) is still regarded as a standard treatment for muscle-invasive bladder cancer, laparoscopic and robot-assisted RC are becoming more popular. Robotic RC can be safely performed with acceptably low risk of blood loss, transfusion, and intraoperative complications; however, as for open RC, the risk of postoperative complications is high, including a substantial risk of major complication and reoperation. Robot-assisted radical cystectomy (RC) can be performed safely with acceptable perioperative outcome, although complications are common. Cumulative analyses demonstrated that operative time was shorter with open RC, whereas robot-assisted RC may provide some advantages in terms of blood loss; transfusion rates; and, more limitedly, postoperative complication rates over open and laparoscopic RC.

Tang, K., et al. (2014). "Robotic vs. open radical cystectomy in bladder cancer: A systematic review and meta-analysis." *European Journal of Surgical Oncology*.

Aims: To evaluate the safety and efficacy of robot-assisted radical cystectomy (RARC) compared with open radical cystectomy (ORC) in the treatment of bladder cancer. Methods: A systematic search of Medline, Embase databases and the Cochrane Library was performed to identify studies that compared RARC and ORC and were published up to December 2012. Outcomes of interest included demographic and clinical characteristics, perioperative, pathologic variables and complications. Results: Although there was a significant difference in the operating time in favor of ORC (WMD: 70.69 min; $p < 0.001$), patients having RARC might benefit from significantly fewer total complications (OR: 0.54; $p < 0.001$), less blood loss (WMD: -599.03 ml; $p < 0.001$), shorter length of hospital stay (WMD: -4.56 d; $p < 0.001$), lower blood transfusion rate (OR: 0.13; $p = 0.002$), less transfusion needs (WMD: -2.14 units; $p < 0.001$), shorter time to regular diet (WMD: -1.57 d; $p = 0.002$), more lymph node yield (WMD: 2.18 n; $p = 0.001$) and fewer positive lymph node (OR: 0.64; $p = 0.03$). There was no significant difference between the RARC and ORC regarding positive surgical margins. Conclusions: In early experience, our data suggest

that RARC appears to be a safe, feasible and minimally invasive alternative to its open counterpart when performed by experienced surgeons in selected patients. © 2014 Elsevier Ltd. All rights reserved.

Xia, L., et al. (2015). "Robotic versus Open Radical Cystectomy: An Updated Systematic Review and Meta-Analysis." *PLoS ONE* **10**(3): e0121032.

OBJECTIVE: To critically review the currently available evidence of studies comparing robot-assisted radical cystectomy (RARC) with open radical cystectomy (ORC). METHODS: A comprehensive review of the literature from Pubmed, Web of Science and Scopus was performed in April 2014. All relevant studies comparing RARC with ORC were included for further screening. A pooled meta-analysis of all comparative studies was performed and publication bias was assessed by a funnel plot. RESULTS: Nineteen studies were included for the analysis, including a total of 1779 patients (787 patients in the RARC group and 992 patients in the ORC group). Although RARC was associated with longer operative time ($p < 0.0001$), patients in this group might benefit from significantly lower overall perioperative complication rates within 30 days and 90 days ($p = 0.005$ and 0.0002 , respectively), more lymph node yields ($p = 0.009$), less estimated blood loss ($p < 0.00001$), lower need for perioperative and intraoperative transfusions ($p < 0.0001$ and < 0.0001 , respectively), and shorter postoperative length of stay ($p = 0.0002$). There was no difference between two groups regarding positive surgical margin rates ($p = 0.19$). CONCLUSIONS: RARC appears to be an efficient alternative to ORC with advantages of less perioperative complications, more lymph node yields, less estimated blood loss, lower need for transfusions, and shorter postoperative length of stay. Further studies should be performed to compare the long-term oncologic outcomes between RARC and ORC.

Yuh, B., et al. (2015). "Systematic Review and Cumulative Analysis of Oncologic and Functional Outcomes After Robot-assisted Radical Cystectomy." *European Urology*.

Context: Although open radical cystectomy (ORC) is still the standard approach, laparoscopic radical cystectomy (LRC) and robot-assisted radical cystectomy (RARC) are increasingly performed. Objective: To report on a systematic literature review and cumulative analysis of pathologic, oncologic, and functional outcomes of RARC in comparison with ORC and LRC. Evidence acquisition: Medline, Scopus, and Web of Science databases were searched using a free-text protocol including the terms robot-assisted radical cystectomy or da Vinci radical cystectomy or robot* radical cystectomy. RARC case series and studies comparing RARC with either ORC or LRC were collected. A cumulative analysis was conducted. Evidence synthesis: The searches retrieved 105 papers, 87 of which reported on pathologic, oncologic, or functional outcomes. Most series were retrospective and had small case numbers, short follow-up, and potential patient selection bias. The lymph node yield during lymph node dissection was 19 (range: 3-55), with half of the series following an extended template (yield range: 11-55). The lymph node-positive rate was 22%. The performance of lymphadenectomy was correlated with surgeon and institutional volume. Cumulative analyses showed no significant difference in lymph node yield between RARC and ORC. Positive surgical margin (PSM) rates were 5.6% (1-1.5% in pT2 disease and 0-25% in pT3 and higher disease). PSM rates did not appear to decrease with sequential case numbers. Cumulative analyses showed no significant difference in rates of surgical margins between RARC and ORC or RARC and LRC. Neoadjuvant chemotherapy use ranged from 0% to 31%, with adjuvant chemotherapy used in 4-29% of patients. Only six series reported a mean follow-up of > 36 mo. Three-year disease-free survival (DFS), cancer-specific survival (CSS), and overall survival (OS) rates were 67-76%, 68-83%, and 61-80%, respectively. The 5-yr DFS, CSS, and OS rates were 53-74%, 66-80%, and 39-66%, respectively. Similar to ORC, disease of higher pathologic stage or evidence of lymph node involvement was associated with worse survival. Very limited data were available with respect to functional outcomes. The 12-mo continence rates with continent diversion were 83-100% in men for daytime continence and 66-76% for nighttime continence. In one series, potency was recovered in 63% of patients who were evaluable at 12 mo. Conclusions: Oncologic and functional data from RARC remain

immature, and longer-term prospective studies are needed. Cumulative analyses demonstrated that lymph node yields and PSM rates were similar between RARC and ORC. Conclusive long-term survival outcomes for RARC were limited, although oncologic outcomes up to 5 yr were similar to those reported for ORC. Patient summary: Although open radical cystectomy (RC) is still regarded as the standard treatment for muscle-invasive bladder cancer, laparoscopic and robot-assisted RCs are becoming more popular. Templates of lymph node dissection, lymph node yields, and positive surgical margin rates are acceptable with robot-assisted RC. Although definitive comparisons with open RC with respect to oncologic or functional outcomes are lacking, early results appear comparable. Templates of lymph node dissection, lymph node yields, and positive surgical margin rates are acceptable with robot-assisted cystectomy. Although definitive comparisons to open radical cystectomy with respect to oncologic or functional outcomes are lacking, early results appear comparable.

Prospective Comparative Studies (2)

Lee, R. N., C. K.; Shariat, S. F.; Borkina, A.; Guimento, R.; Brumit, K. F.; Scherr, D. S. (2011). "The economics of robotic cystectomy: cost comparison of open versus robotic cystectomy." BJU International.
Study Type - Therapy (cost minimisation) Level of Evidence 2b OBJECTIVE: * To assess and compare the economic burden of open radical cystectomy (OC) vs robotic-assisted laparoscopic radical cystectomy (RC) with pelvic lymph node dissection and urinary diversion. PATIENTS AND METHODS: * A series of 103 and 83 consecutive patients undergoing OC and RC, respectively, were prospectively studied at a tertiary care institution from April 2002 to February 2009. * Data were collected on patient demographics, perioperative parameters and length of stay (LOS) in hospital. Cohorts were subdivided into ileal conduit (IC), continent cutaneous diversion (CCD) and orthotopic neobladder (ON) subgroups. * A linear cost model was created to simulate treatment with OC vs RC. Procedural costs were derived from the Medicare Resource Based Relative Value Scale. Materials costs were obtained from the respective suppliers. The indirect costs of complications were considered. * Sensitivity analyses were performed. RESULTS: * Despite a higher cost of materials, RC was less expensive than OC for IC and CCD, although the cost advantage deteriorated for ON. * The per-case costs of RC with IC, CCD and ON were \$20 659, \$22 102 and \$22 685, respectively, compared to \$25 505, \$22 697 and \$20 719 for their OC counterparts. * The largest cost driver in the study was LOS in hospital. * RC showed a shorter LOS compared to OC, although this effect was insufficient to offset the higher cost of robotic surgery. * Complications materially affected cost performance. CONCLUSIONS: * Despite a higher cost of materials, RC can be more cost efficient than OC as a treatment for bladder cancer at a high-volume, tertiary care referral centre, particularly with IC. * Complications significantly impact cost performance.

Martin, A. D. N., R. N.; Castle, E. P. (2011). "Robot-assisted radical cystectomy versus open radical cystectomy: A complete cost analysis." Urology **77**(3): 621-625.

Objectives: To perform a complete cost analysis comparing robot assisted radical cystectomy (RARC) versus open radical cystectomy (ORC). Material and Methods After institutional review board approval for data collection, we prospectively recorded perioperative outcomes and costs, such as hospital stay, transfusion rate, readmission rate, and medications for consecutive patients undergoing RARC or ORC. Using actual cost data, we developed a cost decision tree model to determine typical perioperative costs for both RARC and ORC. Multivariate sensitivity analysis was performed to elucidate which variables had the greatest impact on overall cost. Breakeven points with ORC were calculated using our model to better evaluate variable influence. In addition to the above modeled analysis, actual patient costs, including complications 30 days from surgery, were also compared for each procedure. Results Our model analysis showed that operative time and length of stay had the greatest impact on perioperative costs. Robotic cystectomy became more expensive than open cystectomy at the following break-even points: operating room (OR) time greater than 361 minutes, length of stay greater than 6.6 days, or

robotic OR supply cost exceeding \$5853. RARC was 16% more expensive when only comparing direct operative costs. Interestingly, actual total patient costs revealed a 38% cost advantage favoring RARC due to increased hospitalization costs for ORC in our cohort. Conclusions RARC can provide a cost-effective alternative to ORC with operative time and length of stay being the most critical cost determinants. Higher complication rates with ORC make total actual costs much higher than RARC. © 2011 Elsevier Inc.

Large real world retrospective database analysis (3)

Anderson, J. E. C., D. C.; Parsons, J. K.; Talamini, M. A. (2012). "The First National Examination of Outcomes and Trends in Robotic Surgery in the United States." Journal of the American College of Surgeons.

Background: There are few population-based data describing outcomes of robotic-assisted surgery. We compared outcomes of robotic-assisted, laparoscopic, and open surgery in a nationally representative population database. Study Design: A retrospective analysis of the Nationwide Inpatient Sample database from October 2008 to December 2009 was performed. We identified the most common robotic procedures by ICD-9 procedure codes and grouped them into categories by procedure type. Multivariate analyses examined mortality, length of stay (LOS), and total hospital charges, adjusting for age, race, sex, Charlson comorbidity index, and teaching hospital status. Results: A total of 368,239 patients were identified. On adjusted analysis, compared with open, robotic-assisted laparoscopic surgery was associated with decreased odds of mortality (odds ratio = 0.1; 95% CI, 0.0-0.2; $p < 0.001$), decreased mean LOS (-2.4 days; 95% CI, -2.5 to 2.3; $p < 0.001$), and increased mean total charges in all procedures (range \$3,852 to \$15,329) except coronary artery bypass grafting (-\$17,318; 95% CI, -34,492 to -143; $p = 0.048$) and valvuloplasty (not statistically significant). Compared with laparoscopic, robotic-assisted laparoscopic surgery was associated with decreased odds of mortality (odds ratio = 0.1; 95% CI, 0.0-0.6; $p = 0.008$), decreased LOS overall (-0.6 days; 95% CI, -0.7 to -0.5; $p < 0.001$), but increased LOS in prostatectomy and other kidney/bladder procedures (0.3 days; 95% CI, 0.1-0.4; $p = 0.006$; 0.8 days; 95% CI, 0.0-1.6; $p = 0.049$), and increased total charges (\$1,309; 95% CI, 519-2,099; $p = 0.001$). Conclusions: Data suggest that, compared with open surgery, robotic-assisted surgery results in decreased LOS and diminished likelihood of death. However, these benefits are not as apparent when comparing robotic-assisted laparoscopic with nonrobotic laparoscopic procedures. © 2012 American College of Surgeons.

Cohen, S. A., et al. (2014). "Minimally invasive cystectomy is associated with improved perioperative patient safety outcomes compared with open cystectomy in a national cohort." Urology **84**(2): 314-319. Objective To compare perioperative patient safety outcomes of minimally invasive cystectomy (MIC) with open cystectomy (OC) in a national cohort. Comparative outcomes data based on validated metrics are sparse for MIC, an emerging treatment for bladder cancer. Methods We identified patients undergoing MIC and OC for bladder cancer from 2005 to 2010 using the US Nationwide Inpatient Sample. We compared perioperative outcomes using Patient Safety Indicators (PSIs), validated metrics developed by the Agency for Healthcare Research and Quality, and used multivariate regression analyses to generate adjusted odds ratios. Results Between 2005 and 2010, 42,919 patients underwent cystectomy. During this period, the prevalence of MIC increased from 0.8% to 10.3% of all cystectomies. Compared with OC, MIC patients were more likely to be male ($P = .019$) and treated at large teaching hospitals ($P < .001$). There were no significant differences in age, race, Charlson index, or region between groups. The median lengths of stay were 8 and 7 days for OC and MIC, respectively ($P < .001$). In multivariate regression analyses, MIC was associated with a 30% decreased likelihood of any PSI (odds ratio, 0.71; $P = .038$). Although the occurrence of any PSI was associated with increased mortality ($P < .001$), there were no significant differences in mortality between OC and MIC. Conclusion The prevalence of MIC has substantially increased in recent years. Patients

undergoing MIC had superior perioperative patient safety outcomes as measured by PSIs. Further study is needed to explain these patterns and to promote the continued safe diffusion of this technology. © 2014 Elsevier Inc.

Leow, J. J., et al. (2014). "Propensity-Matched Comparison of Morbidity and Costs of Open and Robot-Assisted Radical Cystectomies: A Contemporary Population-Based Analysis in the United States." European Urology.

BACKGROUND: Radical cystectomy (RC) is a morbid procedure associated with high costs. Limited population-based data exist on the complication profile and costs of robot-assisted RC (RARC) compared with open RC (ORC). **OBJECTIVE:** To evaluate morbidity and cost differences between ORC and RARC. **DESIGN, SETTING, AND PARTICIPANTS:** We conducted a population-based, retrospective cohort study of patients who underwent RC at 279 hospitals across the United States between 2004 and 2010. **OUTCOME MEASUREMENTS AND STATISTICAL ANALYSIS:** Multivariable logistic and median regression was performed to evaluate 90-d mortality, postoperative complications (Clavien classification), readmission rates, length of stay (LOS), and direct costs. To reduce selection bias, we used propensity weighting with survey weighting to obtain nationally representative estimates. **RESULTS AND LIMITATIONS:** The final weighted cohort included 34 672 ORC and 2101 RARC patients. RARC use increased from 0.6% in 2004 to 12.8% in 2010. Major complication rates (Clavien grade ≥ 3 ; 17.0% vs 19.8%, $p=0.2$) were similar between ORC and RARC (odds ratio [OR]: 1.32; $p=0.42$). RARC had 46% decreased odds of minor complications (Clavien grade 1-2; OR: 0.54; $p=0.03$). RARC had \$4326 higher adjusted 90-d median direct costs ($p=0.004$). Although RARC had a significantly shorter LOS (11.8 d vs 10.2 d; $p=0.008$), no significant differences in room and board costs existed ($p=0.20$). Supply costs for RARC were significantly higher (\$6041 vs \$3638; $p<0.0001$). Morbidity and cost differences were not present among the highest-volume surgeons (≥ 7 cases per year) and hospitals (≥ 19 cases per year). Limitations include use of an administrative database and lack of oncologic characteristics. **CONCLUSIONS:** The use of RARC has increased between 2004 and 2010. Compared with ORC, RARC was associated with decreased odds of minor but not major complications and with increased expenditures attributed primarily to higher supply costs. Centralization of ORC and RARC to high-volume providers may minimize these morbidity and cost differences. **PATIENT SUMMARY:** Using a US population-based cohort, we found that robotic surgery for bladder cancer decreased minor complications, had no impact on major complications and was more costly than open surgery.

Partial Nephrectomy (with abstract)

- Comprehensive literature search Open Partial Nephrectomy versus Robotic Assisted Partial Nephrectomy versus Conventional Laparoscopic partial nephrectomies – 2010 to 2015
- Study types included: RCTs, prospective comparative studies, systematic reviews with meta-analysis, large (>5000 patients) real world retrospective database studies of established and high quality databases: PREMIERE, SEERS, NSQIP, NIS, Nantional Cancer Database.
- We have hand-picked large French data base study (AHTI) due to the size of the analysis and the local EU relevance
- This is a comprehensive literature search according to the above mentioned inclusion criteria. The search has been done with rigor, but we make no claim of being complete.

Systematic Review and/or Meta-Analysis (9)

Aboumarzouk, O. M. S., R. J.; Eyraud, R.; Haber, G. P.; Chlosta, P. L.; Somani, B. K.; Kaouk, J. H. (2012). "Robotic Versus Laparoscopic Partial Nephrectomy: A Systematic Review and Meta-Analysis." European Urology.

Context: Centres worldwide have been performing partial nephrectomies laparoscopically for greater than a decade. With the increasing use of robotics, many centres have reported their early experiences using it for nephron-sparing surgery. Objective: To review published literature comparing robotic partial nephrectomy (RPN) with laparoscopic partial nephrectomy (LPN). Evidence acquisition: An online systematic review of the literature according to Cochrane guidelines was conducted from 2000 to 2012 including studies comparing RPN and LPN. All studies comparing RPN with LPN were included. The outcome measures were the patient demographics, tumour size, operating time, warm ischaemic time, blood loss, transfusion rates, length of hospital stay, conversion rates, and complications. A meta-analysis of the results was conducted. For continuous data, a Mantel-Haenszel chi-square test was used; for dichotomous data, an inverse variance was used. Each was expressed as a risk ratio with a 95% confidence interval $p < 0.05$ considered significant. Evidence synthesis: A total of 717 patients were included, 313 patients in the robotic group and 404 patients in the laparoscopic group (seven studies). There was no significant difference between the two groups in any of the demographic parameters except for age (age: $p = 0.006$; sex: $p = 0.54$; laterality: $p = 0.05$; tumour size: $p = 0.62$, tumour location: $p = 0.57$; or confirmed malignant final pathology: $p = 0.79$). There was no difference between the two groups regarding operative times ($p = 0.58$), estimated blood loss ($p = 0.76$), or conversion rates ($p = 0.84$). The RPN group had significantly less warm ischaemic time than the LPN group ($p = 0.0008$). There was no difference regarding postoperative length of hospital stay ($p = 0.37$), complications ($p = 0.86$), or positive margins ($p = 0.93$). Conclusions: In early experience, RPN appears to be a feasible and safe alternative to its laparoscopic counterpart with decreased warm ischaemia times noted. © 2012 European Association of Urology.

Choi, J. E., et al. (2015). "Comparison of Perioperative Outcomes Between Robotic and Laparoscopic Partial Nephrectomy: A Systematic Review and Meta-analysis." European Urology.

CONTEXT: Robotic partial nephrectomy (RPN) is rapidly increasing; however, the benefit of RPN over laparoscopic partial nephrectomy (LPN) is controversial. OBJECTIVE: To compare perioperative outcomes of RPN and LPN. EVIDENCE ACQUISITION: We searched Ovid-Medline, Ovid-Embase, the Cochrane Library, KoreaMed, KMBase, KISS, RISS, and KistI from their

inception through August 2013. Two independent reviewers extracted data using a standardized form. Quality of the selected studies was assessed using the methodological index for nonrandomized studies. EVIDENCE SYNTHESIS: A total of 23 studies and 2240 patients were included. All studies were cohort studies with no randomization, and the methodological quality varied. There was no significant difference between the two groups regarding complications of Clavien-Dindo classification grades 1-2 ($p=0.62$), Clavien-Dindo classification grades 3-5 ($p=0.78$), change of serum creatinine ($p=0.65$), operative time ($p=0.35$), estimated blood loss ($p=0.76$), and positive margins ($p=0.75$). The RPN group had a significantly lower rate of conversion to open surgery ($p=0.02$) and conversion to radical surgery ($p=0.0006$), shorter warm ischemia time (WIT; $p=0.005$), smaller change of estimated glomerular filtration rate (eGFR; $p=0.03$), and shorter length of stay (LOS; $p=0.004$). CONCLUSIONS: This meta-analysis shows that RPN is associated with more favorable results than LPN in conversion rate to open or radical surgery, WIT, change of eGFR, and shorter LOS. To establish the safety and effectiveness outcomes of robotic surgery, well-designed randomized clinical studies with long-term follow-up are needed. PATIENT SUMMARY: Robotic partial nephrectomy (PN) is more favorable than laparoscopic PN in terms of lower conversion rate to radical nephrectomy, a favorable renal function indexed estimated glomerular filtration rate, shorter length of hospital stay, and shorter warm ischemia time.

Froghi, S., et al. (2013). "Evaluation of robotic and laparoscopic partial nephrectomy for small renal tumours (T1a)." *BJU International* **112**(4): E322-333.

OBJECTIVE: To compare laparoscopic partial nephrectomy (LPN) with robotic PN (RPN) using meta-analytical techniques, since there has been a rise in the incidence of small renal masses (SRM; <4 cm) minimally invasive approaches are becoming more popular in dealing with such pathologies. MATERIALS AND METHODS: A systematic review of the literature was performed to identify studies comparing LPN and RPN. Comparative studies evaluating RPN and LPN that fulfilled the inclusion criteria were selected. Data on preoperative, operative (operative time, estimated blood loss [EBL], and warm ischaemia time [WIT]), postoperative (length of stay [LOS]) variables and complications were collected. A meta-analysis using random effect model was performed. A further Bland-Altman analysis of some of the operative variables was done to compare their reproducibility and mean difference in techniques. RESULTS: Six studies matched the selection criteria. In all, 256 patients were analyzed (40% RPN and 60% LPN). There was no significant difference in EBL ($P = 0.12$, 95% confidence interval [CI] -12.01 to 104.26). Similarly, there was no significant difference in WIT between the groups ($P = 0.23$, 95% CI -15.22 to 3.70). Also, LOS ($P = 0.22$, 95% CI -0.38 to 0.09) and overall postoperative complication rates were not significantly different between the groups ($P = 0.84$, 95% CI -0.05 to 0.06). CONCLUSIONS: Despite multiple studies reporting better perioperative variables for RPN, the present study found no significant differences between RPN and LPN. This has implications for both the surgeon and the patient. Lack of randomised controlled trials in addition to a lack of long-term oncological data for RPN are current limitations.

Klatte, T., et al. (2013). "Systematic review and meta-analysis of perioperative and oncological outcomes of laparoscopic cryoablation versus laparoscopic partial nephrectomy for the treatment of small renal tumors." *Journal of Urology* **191**(5): 1209-1217.

BACKGROUND: For minimally-invasive treatment of small renal tumors, laparoscopic cryoablation (LCA) has emerged as an alternative procedure to minimally-invasive partial nephrectomy (laparoscopic, LPN; robot-assistant laparoscopic, RPN) for selected patients, but there is still limited data regarding its safety and oncologic efficacy. The purpose of this study was to compare perioperative and oncological outcomes of LCA and LPN/RPN. METHODS: We searched the literature published until September 2013 from MEDLINE, Web of Science, and major conference proceedings. We included studies comparing LCA and LPN/RPN, if they reported oncological or perioperative outcomes. RESULTS: Thirteen retrospective, non-randomized, observational studies met our inclusion criteria. According to the modified Newcastle-Ottawa-

Scale, seven studies (53%) were considered to be of higher quality. Compared with LPN/RPN, LCA was associated with significantly shorter operative times (weighted mean difference (WMD) 35.45 min), lower EBL (WMD 130.11 mL), shorter LOS (WMD 1.22 days), and a lower risk of total (risk ratio (RR) 1.82), urological (RR 1.99) and non-urological complications (RR 2.33). Patients undergoing LCA had a significantly increased risk of local (RR 9.39) and metastatic tumor progression (RR 4.68). CONCLUSIONS: This analysis provides fair evidence that oncological outcomes are substantially worse for LCA than for LPN/RPN, but LCA may be associated with improved perioperative outcomes. Surgical resection may therefore be encouraged in the majority of cases. Balancing cancer control with the risk for perioperative complications is crucial for patient counseling and selection of the appropriate procedure. Prospective, randomized controlled studies with long-term follow-up are needed to confirm our findings.

Laydner, H. K., J. H. (2012). "Robotic partial nephrectomy: The new horizon." *Arab Journal of Urology* **10**(1): 2-9.

Background: There has been an exponential growth in the reporting of series of robotic partial nephrectomy (RPN). We review the technique of RPN and the outcomes from large single-centre series of RPN. Methods: We searched databases to identify original articles related to RPN. For the technical aspects, we describe our technique and provide a general review of previous work. For outcomes, we reviewed previous reports using more rigid criteria, including only single-institution studies with at least 50 patients undergoing RPN. Results: We found seven retrospective studies that met our criteria, with a total of 701 patients. Mean tumour size was 2.8 cm, with an average R.E.N.A.L. score (Radius, tumour size as maximum diameter; Exophytic/endophytic properties of the tumour, Nearness of tumour deepest portion to the collecting system or sinus, Anterior, a/posterior, p, descriptor, and the Location relative to the polar line) of 6.8. The mean warm ischaemia time was 21 min and mean operative duration was 196 min. The mean estimated blood loss was 182 mL, with a 7.4% transfusion rate. The conversion rate was 1.7% and the postoperative complication rate was 14%. The mean length of stay was 3.6 days. There were positive surgical margins in 1.7% of patients. The mean decrease in renal function was 5.4% and the mean follow-up was 8.4 months. Conclusions: RPN is feasible and safe for different levels of complexity of renal tumours. Perioperative outcomes are comparable to those found with more established techniques. Future studies should compare different approaches and prioritise prospective and randomised designs. © 2012 Arab Association of Urology. Production and hosting by Elsevier B.V. All rights reserved.

Mir, S. A. C., J. A.; Sleeper, J. P.; Lotan, Y. (2011). "Cost Comparison of Robotic, Laparoscopic, and Open Partial Nephrectomy." *Journal of Endourology*.

Abstract Purpose: To compare direct costs associated with open partial nephrectomy (OPN), laparoscopic partial nephrectomy (LPN), and robot-assisted LPN (RALPN). Methods: A meta-analysis of nonoverlapping studies was performed to determine operating room (OR) time, equipment use, and length of stay (LOS) for OPN, LPN, and RALPN. Cost models using cost data obtained from our institution were created, and robotic cost and maintenance were amortized over 7 years. One- and two-way sensitivity analyses were performed to evaluate the effect of changing variables on the cost effectiveness of each approach. Results: Seven RALPN, 18 LPN, and 8 OPN data series were identified, comprising a total of 477, 2220, and 2745 procedures, respectively. Weighted mean OR time was 188, 200, 193 minutes; weighted mean LOS was 2.6, 3.2, and 5.9 days for RALPN, LPN, and OPN, respectively. LPN was the most cost-effective approach at a mean direct cost of \$10,311, with a cost advantage of \$1116 and \$1652 over OPN (\$11,427) and RALPN (\$11,962), respectively. Sensitivity analyses demonstrate that significant decreases in robotic costs are required for RALPN to be cost effective. Conclusion: Despite similar OR times, LPN is more cost effective than OPN because of shorter LOS. Because of lower instrumentation costs, LPN is the most cost effective despite a longer LOS than RALPN. RALPN has high cost of maintenance and instrumentation, which is partially compensated by the shorter

LOS. Evidence of oncological and functional equivalence to OPN is warranted to determine the future role of RALPN.

Wu, Z., et al. (2014). "Robotic versus Open Partial Nephrectomy: A Systematic Review and Meta-Analysis." *PLoS ONE* **9**(4): e94878.

OBJECTIVES: To critically review the currently available evidence of studies comparing robotic partial nephrectomy (RPN) and open partial nephrectomy (OPN). **MATERIALS AND METHODS:** A comprehensive review of the literature from Pubmed, Web of Science and Scopus was performed in October 2013. All relevant studies comparing RPN with OPN were included for further screening. A cumulative meta-analysis of all comparative studies was performed and publication bias was assessed by a funnel plot. **RESULTS:** Eight studies were included for the analysis, including a total of 3418 patients (757 patients in the robotic group and 2661 patients in the open group). Although RPN procedures had a longer operative time (weighted mean difference [WMD]: 40.89; 95% confidence interval [CI], 14.39-67.40; $p = 0.002$), patients in this group benefited from a lower perioperative complication rate (19.3% for RPN and 29.5% for OPN; odds ratio [OR]: 0.53; 95%CI, 0.42-0.67; $p < 0.00001$), shorter hospital stay (WMD: -2.78; 95%CI, -3.36 to -1.92; $p < 0.00001$), less estimated blood loss (WMD: -106.83; 95%CI, -176.4 to -37.27; $p = 0.003$). Transfusions, conversion to radical nephrectomy, ischemia time and estimated GFR change, margin status, and overall cost were comparable between the two techniques. The main limitation of the present meta-analysis is the non-randomization of all included studies. **CONCLUSIONS:** RPN appears to be an efficient alternative to OPN with the advantages of a lower rate of perioperative complications, shorter length of hospital stay and less blood loss. Nevertheless, high quality prospective randomized studies with longer follow-up period are needed to confirm these findings.

Zhang, X., et al. (2013). "Comparison of peri-operative outcomes of robot-assisted vs laparoscopic partial nephrectomy: a meta-analysis." *BJU International*.

OBJECTIVE: To conduct a meta-analysis of the literature on the peri-operative outcomes of both robot-assisted partial nephrectomy (RAPN) and laparoscopic partial nephrectomy (LPN). **MATERIALS AND METHODS:** An electronic database search of MEDLINE, EMBASE, Google Scholar and the Cochrane Library was performed for publications up to 8 January 2013. All studies comparing RAPN with LPN were included. The outcome measures were demographic and peri-operative results, including operating time, warm ischaemia time, blood loss, length of hospital stay, conversion rates, positive surgical margins and complications. A meta-analysis of the results was conducted. **RESULTS:** A total of 766 patients were included, 425 patients in the RAPN group and 341 patients in the LPN group. There was no significant difference between the two groups in any of the demographic variables (age: $P = 0.89$; sex: $P = 0.31$; malignant pathology: $P = 0.54$; tumour size: $P = 0.99$; tumour laterality: $P = 0.06$). There was no difference between the two groups regarding operating times ($P = 0.75$), estimated blood loss ($P = 0.75$), conversion rates ($P = 0.52$), positive surgical margins ($P = 0.61$), complications ($P = 0.27$) or length of hospital stay ($P = 0.27$), but the RAPN group had significantly shorter warm ischaemia times than the LPN group ($P = 0.01$; weighted mean difference: -3.65; 95% confidence interval, -6.46 to -0.83). **CONCLUSION:** This meta-analysis shows that RAPN provides equivalent peri-operative outcomes to those of LPN, with the added advantage of a significantly shorter warm ischaemia time.

Zhang, X., et al. (2014). "Robot-assisted versus laparoscopic partial nephrectomy for localized renal tumors: a meta-analysis." *International Journal of Clinical and Experimental Medicine* **7**(12): 4770-4779.

BACKGROUND: Robot-assisted partial nephrectomy (RAPN) is being performed more frequently for the minimally invasive management of localized renal tumors. However, it's unclear whether RAPN is more efficacious than the standard laparoscopic partial nephrectomy (LPN). The objective of this meta-analysis is to compare RAPN and LPN in terms of perioperative and oncologic outcomes for the treatment of localized renal tumors. **METHODS:** A systematic search

of electronic databases including MEDLINE, EMBASE and OVID was conducted. Comparative studies comparing RAPN and LPN for the treatment of localized renal tumors were regarded eligible. The mean difference (MD), odds ratio (OR) and their corresponding 95% confidence intervals (CI) were calculated for each outcome. The methodologic quality of the included studies was evaluated using the strict criteria of the Newcastle-Ottawa scale. RESULTS: 14 comparative studies (n = 1539 participants) were included in the present meta-analysis. Operative time was similar for RAPN and LPN (MD = 6.33, 95% CI [-23.93, 36.59]), however, warm ischemia time favored RAPN (MD = -3.29, 95% CI [-6.47, -0.10]). There was no significant difference in estimated blood loss (EBL) (MD = -42.24, 95% CI [-87.10, 2.61]) and length of stay (LOS) (MD = -0.29, 95% CI [-0.89, 0.32]). The incidence of intraoperative complications was similar for RAPN and LPN (OR = 0.68, 95% CI [0.29, 1.58]), as well as incidence of postoperative minor complications (OR = 1.10, 95% CI [0.80, 1.51]) and postoperative major complications distributions by Clavien classification (OR = 0.99, 95% CI [0.61, 1.61]). In addition, no significant difference was found in terms of positive surgical margin rate (OR = 1.12, 95% CI [0.56, 2.25]). CONCLUSIONS: RAPN had similar operative time, LOS, EBL, and perioperative complications compared with LPN, as well as positive margin rates. RAPN appears to offer the advantage of decreased WIT compared with LPN. Studies with long-term follow up are needed to compare RAPN and LPN in terms of long-term complications and oncologic outcomes

Prospective Comparative Studies (4)

Masson-Lecomte, A., et al. (2013). "A prospective comparison of the pathologic and surgical outcomes obtained after elective treatment of renal cell carcinoma by open or robot-assisted partial nephrectomy." Urologic Oncology: Seminars and Original Investigations **31**(6): 924-929.

To prospectively compare surgical and pathologic outcomes obtained by elective robot-assisted (RAPN) or open partial nephrectomy (OPN) for small renal cell carcinoma (RCC). Between 2008 and 2010, after protocol design and patient consent, we prospectively collected clinical data for 100 patients who concurrently underwent either OPN (58) or RAPN (42) by an individual experienced surgeon. Clinical data included age, BMI, and past medical history. Operative data included operative time, warm ischemia time (WIT), and estimated blood loss (EBL). Postoperative outcomes included hospital stay (LOS), creatinine variation, Clavien complications, pathologic results, and survival. We stratified the complexity of the renal tumor using the R.E.N.A.L Nephrometry score. Of note, RAPN was superior to OPN in terms of EBL (median 143 mL vs. 415; $P < 0.001$) and LOS (median 3.8 days vs. 6.8; $P < 0.0001$). The median WIT for the RAPN group was 17.5 minutes (vs. 17.1 OPN; $P = 0.3$) and the mean strict operative time was 134.8 minutes (vs. 128.4 OPN; $P = 0.097$). Regarding immediate, early, and short-term complications, variation of creatinine levels, and pathologic margins, the rates were equivalent for both groups ($P > 0.05$). According to the R.E.N.A.L nephrometry scores, both groups (RAPN/OPN) had similar rates (%) of low (81/72.4) and intermediate (19/20.7) complexity tumors, though there were 4 high complexity tumors in OPN group (vs. 0; $P = 0.03$). We found that RAPN is superior to the reference standard (OPN) surgical treatment of small RCCs in terms of blood loss and length of hospital stay with equivalent complications, warm ischemia time, and effect on renal function. Larger randomized trials with longer follow-up will give us further information and insight into the oncologic equivalence. © 2013 Elsevier Inc.

Masson-Lecomte, A. B., K.; Seringe, E.; Vaessen, C.; de la Taille, A.; Doumerc, N.; Rischmann, P.; Bruyere, F.; Soustelle, L.; Droupy, S.; Roupret, M. (2013). "A prospective comparison of surgical and pathological outcomes obtained after robot-assisted or pure laparoscopic partial nephrectomy in moderate to complex renal tumours: results from a French multicentre collaborative study." BJU International **111**(2): 256-263.

Nephron-sparing surgery has become the standard of care for small renal masses because it allows for the same oncological control as radical nephrectomy and achieves better overall survival, while lowering the risk of subsequent chronic renal failure. Mini-invasive surgical

approaches have also been developed, e.g. laparoscopic partial nephrectomy (LPN) and robot-assisted laparoscopic PN (RAPN), which result in less bleeding, reduced postoperative pain, shorter length of stay (LOS) and shorter recovery time. LPN requires advanced surgical skill, has a longer learning curve and requires perseverance, which limits its large diffusion. From this prospective comparative study, we can now claim that RAPN is not inferior to pure LPN in terms of perioperative outcomes (i.e. blood loss, operative duration, warm ischaemia time, LOS).

OBJECTIVE: To prospectively compare the surgical and pathological outcomes obtained with robot-assisted laparoscopic partial nephrectomy (RAPN) or laparoscopic PN (LPN) for renal cell carcinoma in a multicentre cohort. **PATIENTS AND METHODS:** Between 2007 and 2011, 265 nephron-sparing surgeries were performed at six French urology departments. The patients underwent either RAPN (n = 220) or LPN (n = 45) procedures. The operative data included operative duration, warm ischaemia time (WIT) and estimated blood loss (EBL). The postoperative outcomes included length of stay (LOS), creatinine variation (Modification of Diet in Renal Disease group), Clavien complications and pathological results. The complexity of the renal tumour was classified using the R.E.N.A.L. nephrometry scoring system. Student's t-test and chi-squared tests were used to compare variables. **RESULTS:** The median follow-ups for the RAPN and LPN groups were 7 and 18 months, respectively (P < 0.001). Age and American Society of Anesthesiology score were significantly higher in the LPN group (P = 0.02 and P = 0.004, respectively). These variables were lower in the RAPN group: WIT [mean (sd) 20.4 (9.7) vs 24.3 (15.2) min; P = 0.03], operative duration [mean (sd) 168.1 (55.5) vs 199.7 (51.2) min; P < 0.001], operating room occupation time [mean (sd) 248.3 (66.7) vs 278.2 (71.3) min; P = 0.008], EBL [mean (sd) 244.8 (365.4) vs 268.3 (244.9) mL; P = 0.01], use of haemostatic agents [used in 78% of RAPNs and 100% of LPNs; P < 0.001] and LOS [mean (sd) 5.5 (4.3) vs 6.8 (3.2) days; P = 0.05]. There were no significant differences between pre- and postoperative creatinine levels, pathology report or complication rates between the groups. The main limitation was due to the study's non-randomised design. **CONCLUSION:** RAPN is not inferior to pure LPN for perioperative outcomes (i.e. EBL, operative duration, WIT, LOS). Only a randomised study with a longer follow-up can now provide further insight into oncological outcomes.

Sukumar, S. P., F.; Mander, N.; Chen, R.; Menon, M.; Rogers, C. G. (2011). "Robotic partial nephrectomy using robotic bulldog clamps." *Journal of the Society of Laparoendoscopic Surgeons* **15**(4): 520-526.

Background and Objectives: The need for a skilled assistant to perform hilar clamping during robotic partial nephrectomy is a potential limitation of the technique. We describe our experience using robotic bulldog clamps applied by the console surgeon for hilar clamping. **Methods:** A total of 60 consecutive patients underwent robotic partial nephrectomy, 30 using laparoscopic bulldog clamps applied by the assistant and 30 using robotic bulldog clamps applied with the robotic Prograsp instrument. Perioperative outcomes were compared between groups. **Results:** All 30 patients underwent successful hilar clamping during robotic partial nephrectomy using robotic bulldog clamps with no intraoperative complications and without the need for readjustment/reclamping. Robotic bulldog clamps provided adequate ischemia even for tumors >4 cm, hilar, endophytic, multiple tumors, and multiple renal arteries. Both groups had similar baseline characteristics. Perioperative outcomes with robotic bulldog clamps were at least comparable to the laparoscopic bulldog group, with a trend to lower console time, warm ischemia time, and estimated blood loss. **Conclusions:** Use of robotically applied bulldog clamps is a safe and feasible method of hilar occlusion during robotic partial nephrectomy; they perform at least as well as laparoscopic bulldog clamps while allowing the console surgeon greater autonomy and precision for hilar clamping. © 2011 by JSLS, Journal of the Society of Laparoendoscopic Surgeons.

Vittori, G. (2013). "Open versus robotic-assisted partial nephrectomy: a multicenter comparison study of perioperative results and complications." *World Journal of Urology* **32**(1): 287-293.

PURPOSE: To compare surgical results, morbidity and positive surgical margins rate of patients undergoing robotic partial nephrectomy (RPN) versus open partial nephrectomy (OPN).
METHODS: This is an observational multicenter study promoted by the "Associazione Giovani Laparoscopisti Endoscopisti" (AGILE) no-Profit Foundation, which involved six Italian urologic centers. All clinical, surgical, and pathological variables of patients treated with OPN or RPN for renal tumors were gathered in a prospectively maintained database. Tumor nephrometry was measured with PADUA score, and complications were stratified with modified Clavien system. Differences between RPN and OPN group were assessed with univariate analysis. Perioperative variables independently associated with complications were assessed with multivariate analysis.
RESULTS: A total of 198 and 105 patients were enrolled in OPN and RPN group, respectively. Both had similar demographics, indications to surgery, tumor nephrometry, renal function, WIT (18.7 vs. 18.2 min; $p = \text{NS}$), positive margin rate (5.6 vs. 5.7 %; $p = \text{NS}$), intraoperative complications, and postoperative medical complications. Compared to OPN, RPN group was significantly more morbid ($p = 0.04$), included tumors with smaller size ($p = 0.002$), had longer operative time ($p < 0.001$), lower blood loss, surgical postoperative complications (5.7 vs. 21.2 %, $p < 0.001$), Clavien 3-4 surgical complications (1 vs. 9.1 %, $p = 0.001$), and shorter hospitalization. The surgical approach resulted independently correlated with surgical complications on multivariate analysis. **CONCLUSION:** In the present series, RPN was associated with a significant reduction of blood loss, surgical complications, including the reintervention rate for urinary fistula and postoperative bleeding, and with a shorter hospitalization.

Large real world database (4)

Ghani, K. R., et al. (2014). "Practice Patterns and Outcomes of Open and Minimally Invasive Partial Nephrectomy Since the Introduction of Robotic Partial Nephrectomy: Results from the Nationwide Inpatient Sample." Journal of Urology.

Purpose: We determined practice patterns and perioperative outcomes of open and minimally invasive partial nephrectomy in the United States since the introduction of a robot-assisted modifier in the Nationwide Inpatient Sample. **Materials and Methods:** We identified all patients with nonmetastatic disease treated with open, laparoscopic or robotic partial nephrectomy in the Nationwide Inpatient Sample between October 2008 and December 2010. Utilization rates were assessed by year, patient and hospital characteristics. We evaluated the perioperative outcomes of open vs robotic and open vs laparoscopic partial nephrectomy using binary logistic regression models adjusted for patient and hospital covariates. **Results:** In a weighted sample of 38,064 partial nephrectomies 66.9%, 23.9% and 9.2% of the procedures were open, robotic and laparoscopic operations, respectively. In 2010 the relative annual increase in open, robotic and laparoscopic partial nephrectomy was 7.9%, 45.4% and 6.1%, respectively. Compared to open partial nephrectomy patients treated with minimally invasive partial nephrectomy were less likely to receive blood transfusion (robotic vs laparoscopic OR 0.56, $p < 0.001$ vs OR 0.68, $p = 0.016$), postoperative complication (OR 0.63, $p < 0.001$ vs OR 0.78, $p < 0.009$) or prolonged length of stay (OR 0.27 vs OR 0.41, each $p < 0.001$). Only patients who underwent the robotic procedure were less likely to experience an intraoperative complication (robotic vs laparoscopic OR 0.69, $p = 0.014$ vs OR 0.67, $p = 0.069$). Excess hospital charges were higher after robotic surgery (OR 1.35, $p < 0.001$). **Conclusions:** The dissemination of robotic surgery for partial nephrectomy in the United States has been rapid and safe. Compared to open partial nephrectomy the robotic procedure had lower odds than laparoscopic partial nephrectomy for most study outcomes except hospital charges. Robotic partial nephrectomy has now supplanted laparoscopic partial nephrectomy as the most common minimally invasive approach for partial nephrectomy. © 2014 American Urological Association Education and Research, Inc.

Kardos, S. V., et al. (2014). "Association of Type of Renal Surgery and Access to Robotic Technology for Kidney Cancer: Results From A Population-Based Cohort." BJU International.

INTRODUCTION: While high volume and academic hospitals have been associated with greater use of partial nephrectomy (PN) performed for renal cell carcinoma (RCC), the effect of robotic technology on PN use remains unknown. Therefore, we sought to evaluate the relationship of PN and hospital availability of robotic surgery from a population-based cohort in the U.S. METHODS: After merging the Nationwide Inpatient Sample (NIS) and the American Hospital Association (AHA) survey from 2006 to 2008, we identified 21,179 patients who underwent either PN or radical nephrectomy (RN) for RCC. The primary outcome was the type of nephrectomy performed. Multivariable logistic regression identified patient and hospital characteristics associated with receipt of PN. RESULTS: We identified 4,832 (22.8%) and 16,347 (77.2%) patients who were treated for RCC with PN and RN, respectively. On multivariable analysis, patients were more likely to receive PN at academic (OR: 2.77; $p < 0.001$), urban (OR: 3.66; $p < 0.001$), and American College of Surgeon (ACOS) designated cancer centers (OR: 1.10; $p < 0.05$) compared to non-academic, rural, and non-designated cancer center hospitals, respectively. Robotic availability at a hospital was associated with higher adjusted odds of PN compared centers without robotic surgery (OR: 1.28; $p < 0.001$). CONCLUSIONS: While academic and urban locations are established characteristics influencing receipt of PN for RCC, the presence of robotic surgery at a hospital was also independently associated with higher use of PN. Our results are informative in identifying other key hospital characteristics which may facilitate greater adoption of PN.

Ouzaid, I., et al. (2014). "[Practice uptake in France before and after the 2010 French guidelines on kidney cancer]." *Progres en Urologie* **24**(5): 257-261.

INTRODUCTION AND OBJECTIVE: Compared to the 2007 edition, the 2010 French urological association onco-urology guidelines boarded the indications of partial nephrectomy (PN) as long as the procedure is technically feasible. The aim of this study was to assess national practice with respect to kidney surgery in the 2 years before and after current guidelines. MATERIALS AND METHODS: The national database of the Agence Technique de l'Information sur l'Hospitalisation (ATIH) was queried for procedures performed between 2009 and 2010 (era 1) and between 2011 and 2012 (era 2). The coding system of the Classification Commune des Actes Medicaux (CCAM) was used to extract kidney related procedures. For each era, procedures were sorted into partial versus radical nephrectomy (RN), laparoscopic/robotic versus open approach, and private versus public hospital. The two eras were then compared. RESULTS: Overall, 28,000 and 28,907 procedures were reported in era 1 and 2 with mean 14,000 and 14,450 procedures per year respectively. PN increased from 30% to 35% ($P < 0.0001$) between the two eras. This uptake was similar in public and private hospitals. Accordingly, laparoscopic/robotic approach has significantly increased between the two eras (35% versus 39%, $P < 0.0001$) and even more importantly in public hospitals ($P = 0.0017$). There was a significant increase in laparoscopic/robotic PN as well as a decrease in open RN over the years of the study period. CONCLUSION: This study showed the development of PN and the minimally invasive approach. Over the study period, minimally invasive procedure uptake was higher in public hospitals.

Tabayoyong, W., et al. (2015). "Variation in Surgical Margins Status by Surgical Approach Among Patients Undergoing Partial Nephrectomy for Small Renal Masses." *Journal of Urology*.

PURPOSE: We assessed the relationship of surgical margins across different surgical approaches to partial nephrectomy for patients with clinical T1a renal cell carcinoma (RCC) from a population-based cohort. MATERIALS AND METHODS: We used the National Cancer Database to identify all patients who received a partial nephrectomy for clinical T1a RCC (tumor size < 4 cm) from 2010 to 2011. The primary outcome was surgical margin status among patients undergoing partial nephrectomy with either the open, laparoscopic, or robotic approach. Multivariable logistic regression analysis identified patient, hospital, and surgical factors associated with positive surgical margins. RESULTS: Among 11,587 patients who underwent partial nephrectomy, 44% ($n = 5,094$) had open, 14% ($n = 1,681$) had laparoscopic, and 42% ($n = 4,812$) had robotic. Mean age was 56 (SD: 12 years). Overall, 7% of patients had positive surgical margins ($n = 806$). The

positive surgical margins prevalence was 4.9%, 8.1%, and 8.7% for open, laparoscopic, and robotic approaches, respectively ($p < 0.001$). Laparoscopic (OR: 1.81; $p < 0.001$) and robotic partial nephrectomy (OR: 1.79; $p < 0.001$) had higher adjusted odds ratios for positive surgical margins compared to open. When stratified by hospital type, differences in positive surgical margin rates remained such that patients treated at academic medical centers who underwent laparoscopic (OR 1.38; $p = 0.074$) or robotic partial nephrectomy (OR 1.73; $p < 0.001$) had higher adjusted odds ratios compared to patients treated with open partial nephrectomy. CONCLUSIONS: Laparoscopic and robotic partial nephrectomy are associated with higher positive surgical margin rates compared to open partial nephrectomy for clinical T1a renal cell carcinomas. The effect of margin status on long-term oncological outcomes in this context remains to be determined.

Nephrectomy

- Comprehensive literature search Open Nephrectomy versus Robotic Assisted Nephrectomy versus conventional laparoscopic nephrectomy – 2010 to 2015
- Study types included: RCTs, prospective comparative studies, systematic reviews with meta-analysis, large (>5000 patients) real world retrospective database studies of established and high quality databases: PREMIERE, SEERS, NSQIP, NIS. HTAs
- This is a comprehensive literature search according to the above mentioned inclusion criteria. The search has been done with rigor, but we make no claim of being complete.

Systematic Review and/or Meta-Analysis (2)

Asimakopoulos, A. D., et al. (2014). "Robotic radical nephrectomy for renal cell carcinoma: a systematic review." *BMC Urology* **14**: 75.

BACKGROUND: Laparoscopic radical nephrectomy (LRN) is the actual gold-standard for the treatment of clinically localized renal cell carcinoma (RCC) (cT1-2 with no indications for nephron-sparing surgery). Limited evidence is currently available on the role of robotics in the field of radical nephrectomy. The aim of the current study was to provide a systematic review of the current evidence on the role of robotic radical nephrectomy (RRN) and to analyze the comparative studies between RRN and open nephrectomy (ON)/LRN. **METHODS:** A Medline search was performed between 2000-2013 with the terms "robotic radical nephrectomy", "robot-assisted laparoscopic nephrectomy", "radical nephrectomy". Six RRN case-series and four comparative studies between RRN and (ON)/pure or hand-assisted LRN were identified. **RESULTS:** Current literature produces a low level of evidence for RRN in the treatment of RCC, with only one prospective study available. Mean operative time (OT) ranges between 127.8-345 min, mean estimated blood loss (EBL) ranges between 100-273.6 ml, and mean hospital stay (HS) ranges between 1.2-4.3 days. The comparison between RRN and LRN showed no differences in the evaluated outcomes except for a longer OT for RRN as evidenced in two studies. Significantly higher direct costs and costs of the disposable instruments were also observed for RRN. The comparison between RRN and ON showed that ON is characterized by shorter OT but higher EBL, higher need of postoperative analgesics and longer HS. **CONCLUSIONS:** No advantage of robotics over standard laparoscopy for the treatment of clinically localized RCC was evidenced. Promising preliminary results on oncologic efficacy of RRN have been published on the T3a-b disease. Fields of wider application of robotics should be researched where indications for open surgery still persist.

MacLennan, S. I., M.; Lapitan, M. C.; Omar, M. I.; Lam, T. B. L.; Hilvano-Cabungcal, A. M.; Royle, P.; Stewart, F.; MacLennan, G.; MacLennan, S. J.; Dahm, P.; Canfield, S. E.; McClinton, S.; Griffiths, T. R. L.; Ljungberg, B.; N'Dow, J. (2012). "Systematic review of perioperative and quality-of-life outcomes following surgical management of localised renal cancer." *European Urology* **62**(6): 1097-1117.

Context: For the treatment of localised renal cell carcinoma (RCC), uncertainties remain over the perioperative and quality-of-life (QoL) outcomes for the many different surgical techniques and approaches of nephrectomy. Controversy also remains on whether newer minimally invasive nephron-sparing interventions offer better QoL and perioperative outcomes, and whether adrenalectomy and lymphadenectomy should be performed simultaneously with nephrectomy. These non-oncological outcomes are important because they may have a considerable impact on localised RCC treatment decision making. **Objective:** To review systematically all the relevant published literature comparing perioperative and QoL outcomes of surgical management of localised RCC (T1-2N0M0). **Evidence acquisition:** Relevant databases including Medline, Embase, and the Cochrane Library were searched up to January 2012. Randomised controlled trials (RCTs) or quasi-randomised controlled trials, prospective observational studies with controls,

retrospective matched-pair studies, and comparative studies from well-defined registries/databases were included. The outcome measures were QoL, analgesic requirement, length of hospital stay, time to normal activity level, surgical morbidity and complications, ischaemia time, renal function, blood loss, length of operation, need for blood transfusion, and perioperative mortality. The Cochrane risk of bias tool was used to assess RCTs, and an extended version was used to assess nonrandomised studies (NRSs). The quality of evidence was assessed using Grading of Recommendations, Assessment, Development, and Evaluation. Evidence synthesis: A total of 4580 abstracts and 380 full-text articles were assessed, and 29 studies met the inclusion criteria (7 RCTs and 22 NRSs). There were high risks of bias and low-quality evidence for studies meeting the inclusion criteria. There is good evidence indicating that partial nephrectomy results in better preservation of renal function and better QoL outcomes than radical nephrectomy regardless of technique or approach. Regarding radical nephrectomy, the laparoscopic approach has better perioperative outcomes than the open approach, and there is no evidence of a difference between the transperitoneal and retroperitoneal approaches. Alternatives to standard laparoscopic radical nephrectomy (LRN) such as hand-assisted, robot-assisted, or single-port techniques appear to have similar perioperative outcomes. There is no good evidence to suggest that minimally invasive procedures such as cryotherapy or radiofrequency ablation have superior perioperative or QoL outcomes to nephrectomy. Regarding concomitant lymphadenectomy during nephrectomy, there were low event rates for complications, and no definitive difference was observed. There was no evidence to base statements about concomitant ipsilateral adrenalectomy during nephrectomy. Conclusions: Partial nephrectomy results in significantly better preservation of renal function over radical nephrectomy. For tumours where partial nephrectomy is not technically feasible, there is no evidence that alternative procedures or techniques are better than LRN in terms of perioperative or QoL outcomes. In making treatment decisions, perioperative and QoL outcomes should be considered in conjunction with oncological outcomes. Overall, there was a paucity of data regarding QoL outcomes, and when reported, both QoL and perioperative outcomes were inconsistently defined, measured, or reported. The current evidence base has major limitations due to studies of low methodological quality marked by high risks of bias. © 2012 European Association of Urology.

Prospective Comparative Analysis (1)

Anderberg, M. K., C. C.; Arnbjörnsson, E. (2011). "Paediatric computer-assisted retroperitoneoscopic nephrectomy compared with open surgery." *Pediatric Surgery International*: 1-7.

Purpose: Computer-assisted laparoscopic surgery (CALs) in children is increasingly used and has proven to be feasible and safe. However, its full potential remains unclear and clinical comparative studies hardly exist. The aim of this study was to prospectively evaluate our experience with CALs for performing retroperitoneal nephrectomies in children when compared with controls undergoing open surgery in terms of safety, operative time, blood loss, opioid requirements, the duration of hospital stay and complications. Children and methods: Computer-assisted retroperitoneoscopic nephrectomy was undertaken in ten consecutive children, mean age at the time of surgery 6.4 (SD ± 4.5) years, and compared with a retrospectively collected control group of all other children, mean age 3.9 (SD ± 4.6) years, who underwent the same procedure by conventional open surgery between the years 2005 and 2009. The endpoint of the study was 1 month postoperatively. Results: Nephrectomies were performed in all the children and no child was excluded from the study. There was no per-operative complication in any of the groups. The median (range) operative time was 202 (128-325) and 72 (44-160) min for the CALs and open group, respectively. The blood loss was minimal (<20 ml) for all the patients. The postoperative opioid requirements did not differ. The median (range) postoperative hospital stay was 1 (1-4) and 2 (1-7) days for the CALs and the open group, respectively. One complication in the form of an urinoma appeared 5 days after surgery in the CALs group. Conclusion: Computer-assisted retroperitoneoscopic nephrectomy is a safe, feasible and effective procedure in children. Even though operative times are longer the patients benefit from the lower morbidity, improved

cosmetics and shorter hospitalization associated with the minimally invasive approach. © 2011 Springer-Verlag.

Large Real World Database Analysis (1)

Yang, D. Y., et al. (2014). "Does robotic assistance confer an economic benefit during laparoscopic radical nephrectomy?" *Journal of Urology* **192**(3): 671-676.

PURPOSE: While robotic assisted radical nephrectomy is safe with outcomes and complication rates comparable to those of the pure laparoscopic approach, there is little evidence of an economic or clinical benefit. **MATERIALS AND METHODS:** From the 2009 to 2011 Nationwide Inpatient Sample database we identified patients 18 years old or older who underwent radical nephrectomy for primary renal malignancy. Robotic assisted and laparoscopic techniques were noted. Patients treated with the open technique and those with evidence of metastatic disease were excluded from analysis. Descriptive statistics were performed using the chi-square and Mann-Whitney tests, and the Student t-test. Multiple linear regression was done to examine factors associated with increased hospital costs and charges. **RESULTS:** We identified 24,312 radical nephrectomy cases for study inclusion, of which 7,787 (32%) were performed robotically. There was no demographic difference between robotic assisted and pure laparoscopic radical nephrectomy cases. Median total charges were \$47,036 vs \$38,068 for robotic assisted vs laparoscopic surgery ($p < 0.001$). Median total hospital costs for robotic assisted surgery were \$15,149 compared to \$11,735 for laparoscopic surgery ($p < 0.001$). There was no difference in perioperative complications or the incidence of death. Compared to the laparoscopic approach robotic assistance conferred an estimated \$4,565 and \$11,267 increase in hospital costs and charges, respectively, when adjusted for adapted Charlson comorbidity index score, perioperative complications and length of stay ($p < 0.001$). **CONCLUSIONS:** Robotic assisted radical nephrectomy results in increased medical expense without improving patient morbidity. Assuming surgeon proficiency with pure laparoscopy, robotic technology should be reserved primarily for complex surgeries requiring reconstruction. Traditional laparoscopic techniques should continue to be used for routine radical nephrectomy.

GYN Cancer

- Comprehensive literature search Open GYN cancer surgery versus Robotic Assisted GYN cancer surgery versus Conventional laparoscopic GYN cancer surgery – 2010 to 2015
- Study types included: RCTs, prospective comparative studies, systematic reviews with meta-analysis, large (>5000 patients) real world retrospective database studies of established and high quality databases: PREMIERE, SEERS, NSQIP, NIS. HTAs
- This is a comprehensive literature search according to the above mentioned criteria. The search has been done with rigor, but we make no claim of being complete.

RCT (1)

Somashekhar, S. P., et al. (2014). "Prospective Randomized Study Comparing Robotic-Assisted Hysterectomy and Regional Lymphadenectomy with Traditional Laparotomy for Staging of Endometrial Carcinoma -Initial Indian Experience." *Indian J Surg Oncol* 5(3): 217-223.

Robotic assisted hysterectomy with regional lymphadenectomy is increasingly used for the treatment of endometrial carcinoma. In the present study we evaluated the feasibility and technique of robotic assisted hysterectomy and lymphadenectomy in patients with endometrial carcinoma. A prospective randomized study was undertaken from July 2011 to June 2012, in 50 consecutive patients with carcinoma endometrium. Demographic (age, BMI) and perioperative data (operating time, estimated blood loss, total number of lymph nodes retrieved, hospital stay, conversion to open procedure, intraoperative and postoperative complications) of robotic assisted surgery were compared with open staging procedure. Mean age of the patient and BMI in both groups were comparable with no significant difference. Estimated blood loss (81.28 ml), hospital stay (1.94 days) and perioperative complications were significantly less in robotic assisted group in comparison to open method. Mean number of lymph nodes removed were 30.56 versus 27.6 which is suggestive of significant difference statistically. Operative time decreased as the experience of the surgeon increased but still significantly remained higher than the open procedure after 25 robotic assisted surgeries. All robotic surgeries were completed successfully without converting to open method. Robotic assisted staging procedure for endometrial carcinoma is feasible without converting to open method, with the advantages of decreased blood loss, short duration of hospital stay and less postoperative minor complications. Operative time will decrease further as the experience of surgeon increases. Para-aortic lymph node dissection is easily done and with a better ergonomics for surgeon.

Prospective Comparative (5)

Chiou, H., et al. (2014). "Comparing robotic surgery with laparoscopy and laparotomy for endometrial cancer management: A cohort study." *International Journal of Surgery* 13c: 17-22.

Introduction: Robotic surgery has been applied in managing various types of gynecologic cancers. The purpose of this study is to compare the surgical outcomes of robotic surgery, laparoscopy and laparotomy for managing endometrial cancer. Methods: A total of 365 patients received surgical staging for treating IA to IIIC endometrial cancer were retrospectively enrolled. Patient demography, peri-operative parameters, and survival outcomes were studied. Results and discussions: Robotic surgery showed a significant lower blood loss and 24-h pain score as compared to other surgical types. Moreover, compared to laparotomy, robotic and laparoscopic

surgeries were associated with reduced operation time, decreased time to full diet resumption, and shortened hospital stay. No significant differences were found between the groups in terms of overall complication rate. Eighteen-month follow-up of the patients indicated no significant differences in disease-free survival and overall survival. Conclusion: Compared to conventional approaches, robotic surgery showed favorable short-term outcomes with comparable survival. It is suggested that robotic surgery is a feasible tool for endometrial cancer management.

Eklind, S., et al. (2015). "A prospective, comparative study on robotic versus open-surgery hysterectomy and pelvic lymphadenectomy for endometrial carcinoma." International Journal of Gynecological Cancer **25**(2): 250-256.

OBJECTIVES: The aim of this study was to compare surgical outcome, patient recovery, and costs between robot-assisted laparoscopy and laparotomy in women undergoing hysterectomy, bilateral salpingo-oophorectomy (BSOE), and pelvic lymphadenectomy for endometrial carcinoma. **METHODS:** Women undergoing hysterectomy, BSOE, and pelvic lymphadenectomy for endometrial carcinoma, according to regional guidelines, were prospectively, concurrently, and consecutively included from September 2010 to December 2012. Surgical outcomes such as operative time, estimated blood loss (EBL), number of lymph nodes retrieved, and complications were analyzed together with hospital stay, days until normal active daily living was retrieved, patient satisfaction with the length of the hospital stay, and cost per patient. Robot-assisted laparoscopy was performed on all cases at the Sahlgrenska University Hospital, and laparotomy was performed on all cases at 3 regional hospitals. **RESULTS:** Forty women underwent robot-assisted laparoscopy, and 48 underwent laparotomy. There were no differences in age, body mass index, histology, or retrieved lymph nodes. Operative time was significantly shorter in the robot-assisted laparoscopy group ($P < 0.0001$). The EBL was lower and hospital stay was shorter in the robot-assisted laparoscopy group ($P < 0.0001$). There was no statistical difference in complications between the groups, and both groups found hospital stay duration satisfactory. In the robot-assisted laparoscopy group, active daily living was normal within 5 days postoperatively, compared with 14 days in the laparotomy group ($P < 0.0001$). Calculated costs per treated patient did not differ statistically between the groups. **CONCLUSIONS:** Compared with laparotomy and robot-assisted laparoscopic hysterectomy, BSOE pelvic lymphadenectomy for endometrial carcinoma was associated with significantly shorter operative time, hospital stay, and lower EBL. Patients recovered more quickly after robot-assisted laparoscopy, with equal costs number of retrieved lymph nodes, compared with laparotomy.

Fleming, N. D. A., A. E.; Lentz, S. E. (2011). "Operative and anesthetic outcomes in endometrial cancer staging via three minimally invasive methods." Journal of Robotic Surgery: 1-8.

The aim of this work is to compare operative and anesthetic outcomes in patients undergoing minimally invasive endometrial cancer staging, with lymphadenectomy performed via transperitoneal, extraperitoneal, or robotic-assisted methods. Sixty-six consecutive patients (24 transperitoneal, 19 extraperitoneal, and 23 robotic) were identified who underwent laparoscopic-assisted endometrial cancer staging with pelvic and para-aortic lymphadenectomy. Patients were divided into three groups based on method of para-aortic lymphadenectomy. Anesthetic and surgical times were longest in the extraperitoneal group. Patients undergoing robotic surgery had the shortest hospital stay and lowest conversion rate to laparotomy. Patients undergoing robotic lymphadenectomy had more pelvic and para-aortic nodes removed compared with the transperitoneal method. There was no difference in number of para-aortic nodes removed in the robotic versus extraperitoneal methods. The extraperitoneal group had highest peak end-tidal CO₂ levels and highest narcotic requirements, while patients in the robotic group had highest peak inflation pressures and lowest pain scores. There were no differences in complication rates amongst the three groups. Robotic-assisted staging is superior to other minimally invasive methods in terms of most operative outcomes. Extraperitoneal lymphadenectomy is equivalent to robotic surgery where number of aortic nodes is concerned, but is associated with higher end-

tidal CO₂ levels and narcotic requirements. Peak inflation pressures were highest in the robotic group, with no apparent adverse consequences. © 2011 Springer-Verlag London Ltd.

Marino, P., et al. (2015). "Cost-Effectiveness of Conventional vs Robotic-Assisted Laparoscopy in Gynecologic Oncologic Indications." *International Journal of Gynecological Cancer* **25**(6): 1102-1108.

OBJECTIVE: Robotic surgical techniques are known to be expensive, but they can decrease the cost of hospitalization and improve patients' outcomes. The aim of this study was to compare the costs and clinical outcomes of conventional laparoscopy vs robotic-assisted laparoscopy in the gynecologic oncologic indications. METHODS: Between 2007 and 2010, 312 patients referred for gynecologic oncologic indications (endometrial and cervical cancer), including 226 who underwent conventional laparoscopy and 80 who underwent robot-assisted laparoscopy, were included in this prospective multicenter study. The direct costs, operating theater costs, and hospital costs were calculated for both surgical strategies using the microcosting method. RESULTS: Based on an average number of 165 surgical cases performed per year with the robot, the total extra cost of using the robot was \$1456 per intervention. The robot-specific costs amounted to \$2213 per intervention, and the cost of the robot-specific surgical supplies was \$957 per intervention. The cost of the surgical supplies specifically required by conventional laparoscopy amounted to \$1432, which is significantly higher than that of the robotic supplies ($P < 0.001$). Hospital costs were lower in the case of the robotic strategy (\$2380 vs \$2841, $P < 0.001$) because these patients spent less time in intensive care (0.38 vs 0.85 days). Operating theater costs were higher in the case of the robotic strategy (\$1490 vs \$1311, $P = 0.0004$) because the procedure takes longer to perform (4.98 hours vs 4.38 hours). CONCLUSIONS: The main driver of additional costs is the fixed cost of the robot, which is not compensated by the lower hospital room costs. The robot would be more cost-effective if robotic interventions were performed on a larger number of patients per year or if the purchase price of the robot was reduced. A shorter learning curve would also no doubt decrease the operating theater costs, resulting in financial benefits to society.

Soliman, P. T. F., M.; Sun, C. C.; Dos Reis, R.; Schmeler, K. M.; Nick, A. M.; Westin, S. N.; Brown, J.; Levenback, C. F.; Ramirez, P. T. (2011). "Radical hysterectomy: A comparison of surgical approaches after adoption of robotic surgery in gynecologic oncology." *Gynecologic Oncology*.

OBJECTIVE: To compare intra-operative, postoperative and pathologic outcomes of three surgical approaches to radical hysterectomy and bilateral pelvic lymph node dissection over a three year time period during which all three approaches were used. METHODS: We reviewed all patients who underwent radical hysterectomy with pelvic lymph node dissection between 1/2007 and 11/2010. Comparison was made between robotic, laparoscopic and open procedures in regard to surgical times, complication rates, and pathologic findings. RESULTS: A total of 95 radical hysterectomy procedures were performed during the study period: 30 open (RAH), 31 laparoscopic (LRH) and 34 robotic (RRH). There were no differences in age, body mass index or other demographic factors between the groups. Operative time was significantly shorter in the RAH compared to LRH and RRH (265 vs 338 vs 328min, $p=0.002$). Estimated blood loss was significantly lower in LRH and RRH compared with RAH (100 vs 100 vs 350mL, $p<0.001$). Thirteen (24%) of RAH required blood transfusion. Conversion rates were higher in the LRH (16%) compared to RRH (3%) although not significant ($p=0.10$). Median length of stay was significantly shorter in RRH (1day) vs LRH or RAH (2 vs 4days, $p<0.01$). Pathologic findings were similar among all groups. CONCLUSION: Minimally invasive surgery has made a significant impact on patients undergoing radical hysterectomy including decrease in blood loss and transfusion rates however; operative times were significantly longer compared to open radical hysterectomy. Our findings suggest that the robotic approach may have the added benefit of even shorter length of stay compared to traditional laparoscopy.

Systematic Review and/or Meta-Analysis (7)

Gaia, G., et al. (2010). "Robotic-assisted hysterectomy for endometrial cancer compared with traditional laparoscopic and laparotomy approaches: a systematic review." *Obstetrics and Gynecology* **116**(6): 1422-1431.

OBJECTIVE:: To summarize comparative studies describing clinical outcomes of robotic-assisted surgeries compared with traditional laparoscopic or laparotomy techniques for the treatment of endometrial cancer. DATA SOURCES:: Using search words "robotic hysterectomy" and "endometrial cancer," 22 citations were identified from Medline and PubMed (2005 to February 2010). METHODS OF STUDY SELECTION:: We selected English language studies reporting at least 25 robotic cases compared with laparoscopic or laparotomy cases that also addressed surgical technique, complications, and perioperative outcomes. Patients underwent total hysterectomy, bilateral salpingo-oophorectomy, and lymphadenectomy. TABULATION, INTEGRATION, AND RESULTS:: Eight eligible comparative studies were identified that included 1,591 patients (robotic=589, laparoscopic=396, and laparotomy=606). Pooled means of the resected aortic lymph nodes for robotic hysterectomy and laparoscopy were 10.3 and 7.8 (P=.15), and robotic hysterectomy and laparotomy were 9.4 and 5.7 (P=.28). Pooled means of pelvic lymph nodes for robotic and laparoscopic hysterectomy were 18.5 and 17.8 (P=.95) and 18.0 compared with 14.5 (P=.11) for robotic hysterectomy compared with laparotomy. Estimated blood loss was reduced in robotic hysterectomy compared with laparotomy (P<.005) and laparoscopy (P=.001). Length of stay was shorter for both robotic and laparoscopic cases compared with laparotomy (P<.01). Operative time for robotic hysterectomy was similar to laparoscopic cases but was greater than laparotomy (P<.005). Conversion to laparotomy for laparoscopic hysterectomy was 9.9% compared with 4.9% for robotic cases (P=.06). Vascular, bowel, and bladder injuries; cuff dehiscence; and thromboembolic complications were similar for each surgical method. Transfusions for robotic hysterectomy compared with laparotomy was 1.7% and 7.2% (P=.06) and robotic hysterectomy compared with laparoscopy was 2.6% and 5.0% (P=.22). CONCLUSION:: Perioperative clinical outcomes for robotic and laparoscopic hysterectomy appear similar with the exception of less blood loss for robotic cases and longer operative times for robotic and laparoscopy cases.

Geetha, P. and M. Nair (2012). "Laparoscopic, robotic and open method of radical hysterectomy for cervical cancer: A systematic review." *Journal of Minimal Access Surgery* **8**(3): 67-73.

Background : Over the last two decades, numerous studies have indicated the feasibility of minimally invasive surgery for early cervical cancer without compromising the oncological outcome. Objective : Systematic literature review and meta analysis aimed at evaluating the outcome of laparoscopic and robotic radical hysterectomy (LRH and RRH) and comparing the results with abdominal radical hysterectomy (ARH). Search Strategy : Medline, PubMed, Embase, Cochrane library and Reference lists were searched for articles published until January 31 st 2011, using the terms radical hysterectomy, laparoscopic radical hysterectomy, robotic radical hysterectomy, surgical treatment of cervical cancer and complications of radical hysterectomy. Selection Criteria : Studies that reported outcome measures of radical hysterectomy by open method, laparoscopic and robotic methods were selected. Data collection and analysis: Two independent reviewers selected studies, abstracted and tabulated the data and pooled estimates were obtained on the surgical and oncological outcomes. Results : Mean sample size, age and body mass index across the three types of RH studies were similar. Mean operation time across the three types of RH studies was comparable. Mean blood loss and transfusion rate are significantly higher in ARH compared to both LRH and RRH. Duration of stay in hospital for RRH was significantly less than the other two methods. The mean number of lymph nodes obtained, nodal metastasis and positive margins across the three types of RH studies were similar. Post operative infectious morbidity was significantly higher among patients who underwent ARH

compared to the other two methods and a higher rate of cystotomy in LRH. Conclusions : Minimally invasive surgery especially robotic radical hysterectomy may be a better and safe option for surgical treatment of cervical cancer. The laparoscopic method is not free from complications. However, experience of surgeon may reduce the complications rate.

O'Neill, M., et al. (2013). "Robot-assisted hysterectomy compared to open and laparoscopic approaches: systematic review and meta-analysis." *Archives of Gynecology and Obstetrics* **287**(5): 907-918.

Purpose: To review the safety and effectiveness of robot-assisted hysterectomy compared to traditional open and conventional laparoscopic surgery, differentiating radical, simple total with node staging, and simple total hysterectomy. Methods: Medline, Embase, the Cochrane library, and the Journal of Robotic Surgery were searched for controlled trials and observational studies with historic or concurrent controls. Data were pooled using random effects meta-analysis.

Results: Compared to open surgery, robot-assisted radical hysterectomy is associated with reduced hospital stay and blood transfusions. For simple total hysterectomy with node staging, robot-assisted surgery is associated with reduced hospital stay, complications, and blood transfusions compared to open surgery. Compared to conventional laparoscopic surgery, robot-assisted simple total hysterectomy with node staging is associated with complications and conversions. Conclusions: Compared to open surgery, robot-assisted hysterectomy offers benefits for reduced length of hospital stay and blood transfusions. The best evidence of improved outcomes is for simple total hysterectomy with node staging. Study quality was poor. © 2013 Springer-Verlag Berlin Heidelberg.

Ran, L., et al. (2014). "Comparison of robotic surgery with laparoscopy and laparotomy for treatment of endometrial cancer: a meta-analysis." *PLoS ONE* **9**(9): e108361.

PURPOSE: To compare the relative merits among robotic surgery, laparoscopy, and laparotomy for patients with endometrial cancer by conducting a meta-analysis. METHODS: The MEDLINE, Embase, PubMed, Web of Science, and Cochrane Library databases were searched. Studies clearly documenting a comparison between robotic surgery and laparoscopy or between robotic surgery and laparotomy for endometrial cancer were selected. The outcome measures included operating time (OT), number of complications, length of hospital stay (LOHS), estimated blood loss (EBL), number of transfusions, total lymph nodes harvested (TLNH), and number of conversions. Pooled odds ratios and weighted mean differences with 95% confidence intervals were calculated using either a fixed-effects or random-effects model. RESULTS: Twenty-two studies were included in the meta-analysis. These studies involved a total of 4420 patients, 3403 of whom underwent both robotic surgery and laparoscopy and 1017 of whom underwent both robotic surgery and laparotomy. The EBL ($p = 0.01$) and number of conversions ($p = 0.0008$) were significantly lower and the number of complications ($p < 0.0001$) was significantly higher in robotic surgery than in laparoscopy. The OT, LOHS, number of transfusions, and TLNH showed no significant differences between robotic surgery and laparoscopy. The number of complications ($p < 0.00001$), LOHS ($p < 0.00001$), EBL ($p < 0.00001$), and number of transfusions ($p = 0.03$) were significantly lower and the OT ($p < 0.00001$) was significantly longer in robotic surgery than in laparotomy. The TLNH showed no significant difference between robotic surgery and laparotomy. CONCLUSIONS: Robotic surgery is generally safer and more reliable than laparoscopy and laparotomy for patients with endometrial cancer. Robotic surgery is associated with significantly lower EBL than both laparoscopy and laparotomy; fewer conversions but more complications than laparoscopy; and shorter LOHS, fewer complications, and fewer transfusions but a longer OT than laparoscopy. Further studies are required.

Reza, M., et al. (2010). "Meta-analysis of observational studies on the safety and effectiveness of robotic gynaecological surgery." *British Journal of Surgery*.

BACKGROUND:: The safety and effectiveness of robotic, open and conventional laparoscopic surgery in gynaecological surgery was assessed in a systematic review of the literature. This will enable the general surgical community to understand where robotic surgery stands in

gynaecology. METHODS:: A search was made for previous systematic reviews in the Abstracts of Reviews of Effects, Health Technology Assessment, Cochrane Collaboration and Hayes Inc. databases. In addition, the MEDLINE, Embase and CINAHL databases were searched for primary studies. The quality of studies was assessed and meta-analyses were performed. RESULTS:: Twenty-two studies were included in the review. All were controlled but none was randomized. The majority were retrospective with historical controls. The settings in which robotic surgery was used included hysterectomy for malignant and benign disease, myomectomy, sacrocolpopexy, fallopian tube reanastomosis and adnexectomy. Robotic surgery achieved a shorter hospital stay and less blood loss than open surgery. Compared with conventional laparoscopic surgery, robotic surgery achieved reduced blood loss and fewer conversions during the staging of endometrial cancer. No clinically significant differences were recorded for the other indications tested. CONCLUSION:: The available evidence shows that robotic surgery offers limited advantages with respect to short-term outcomes. However, the clinical outcomes should be interpreted with caution owing to the methodological quality of the studies. Copyright (c) 2010 British Journal of Surgery Society Ltd. Published by John Wiley & Sons, Ltd.

Tapper, A. M., et al. (2014). "A systematic review and cost analysis of robot-assisted hysterectomy in malignant and benign conditions." European Journal of Obstetrics Gynecology and Reproductive Biology.

In order to assess the effectiveness and costs of robot-assisted hysterectomy compared with conventional techniques we reviewed the literature separately for benign and malignant conditions, and conducted a cost analysis for different techniques of hysterectomy from a hospital economic database. Unlimited systematic literature search of Medline, Cochrane and CRD databases produced only two randomized trials, both for benign conditions. For the outcome assessment, data from two HTA reports, one systematic review, and 16 original articles were extracted and analyzed. Furthermore, one cost modelling and 13 original cost studies were analyzed. In malignant conditions, less blood loss, fewer complications and a shorter hospital stay were considered as the main advantages of robot-assisted surgery, like any mini-invasive technique when compared to open surgery. There were no significant differences between the techniques regarding oncological outcomes. When compared to laparoscopic hysterectomy, the main benefit of robot-assistance was a shorter learning curve associated with fewer conversions but the length of robotic operation was often longer. In benign conditions, no clinically significant differences were reported and vaginal hysterectomy was considered the optimal choice when feasible. According to Finnish data, the costs of robot-assisted hysterectomies were 1.5-3 times higher than the costs of conventional techniques. In benign conditions the difference in cost was highest. Because of expensive disposable supplies, unit costs were high regardless of the annual number of robotic operations. Hence, in the current distribution of cost pattern, economical effectiveness cannot be markedly improved by increasing the volume of robotic surgery. © 2014 Elsevier Ireland Ltd. All rights reserved.

Zhou, J., et al. (2015). "Robotic vs laparoscopic radical hysterectomy for cervical cancer: a meta-analysis." International of Medical Robots and Computer Assisted Surgery.

BACKGROUND: To evaluate whether the safety and efficacy of robotic radical hysterectomy (RRH) in patients with cervical cancer (CC) are equivalent to those of laparoscopic radical hysterectomy (LRH). METHODS: The Pubmed, Embase, Cochrane Library, Ovid and Web of Science databases were searched. Studies documenting a comparison of RRH with LRH for CC were selected. Operative and recovery outcomes, common morbidity, and oncological parameters were evaluated. RESULTS: Compared with LRH, RRH was associated with less blood loss and shorter hospital stay. There were no significant differences in operative time, complications, mortality, transfusion, conversions, number of retrieved lymph nodes, recurrence or disease-free survival between the two groups. CONCLUSION: RRH for CC is safe and feasible and may be an alternative treatment for CC. More multicentre randomized controlled trials investigating the long-term oncological outcomes are required to determine the advantages of RRH over LRH in CC. Copyright (c) 2015 John Wiley & Sons, Ltd.

HTA (1)

Health Quality, O. (2010). "Robotic-assisted minimally invasive surgery for gynecologic and urologic oncology: an evidence-based analysis." *Ont Health Technol Assess Ser* **10**(27): 1-118.

OBJECTIVE: An application was received to review the evidence on the 'The Da Vinci Surgical System' for the treatment of gynecologic malignancies (e.g. endometrial and cervical cancers). Limitations to the current standard of care include the lack of trained physicians on minimally invasive surgery and limited access to minimally invasive surgery for patients. The potential benefits of 'The Da Vinci Surgical System' include improved technical manipulation and physician uptake leading to increased surgeries, and treatment and management of these cancers. The demand for robotic surgery for the treatment and management of prostate cancer has been increasing due to its alleged benefits of recovery of erectile function and urinary continence, two important factors of men's health. The potential technical benefits of robotic surgery leading to improved patient functional outcomes are surgical precision and vision. **CLINICAL NEED:** Uterine and cervical cancers represent 5.4% (4,400 of 81,700) and 1.6% (1,300 of 81,700), respectively, of incident cases of cancer among female cancers in Canada. Uterine cancer, otherwise referred to as endometrial cancer is cancer of the lining of the uterus. The most common treatment option for endometrial cancer is removing the cancer through surgery. A surgical option is the removal of the uterus and cervix through a small incision in the abdomen using a laparoscope which is referred to as total laparoscopic hysterectomy. Risk factors that increase the risk of endometrial cancer include taking estrogen replacement therapy after menopause, being obese, early age at menarche, late age at menopause, being nulliparous, having had high-dose radiation to the pelvis, and use of tamoxifen. Cervical cancer occurs at the lower narrow end of the uterus. There are more treatment options for cervical cancer compared to endometrial cancer, however total laparoscopic hysterectomy is also a treatment option. Risk factors that increase the risk for cervical cancer are multiple sexual partners, early sexual activity, infection with the human papillomavirus, and cigarette smoking, whereas barrier-type of contraception as a risk factor decreases the risk of cervical cancer. Prostate cancer is ranked first in men in Canada in terms of the number of new cases among all male cancers (25,500 of 89,300 or 28.6%). The impact on men who develop prostate cancer is substantial given the potential for erectile dysfunction and urinary incontinence. Prostate cancer arises within the prostate gland, which resides in the male reproductive system and near the bladder. Radical retropubic prostatectomy is the gold standard treatment for localized prostate cancer. Prostate cancer affects men above 60 years of age. Other risk factors include a family history of prostate cancer, being of African descent, being obese, consuming a diet high in fat, physical inactivity, and working with cadmium. **THE DA VINCI SURGICAL SYSTEM:** The Da Vinci Surgical System is a robotic device. There are four main components to the system: 1) the surgeon's console, where the surgeon sits and views a magnified three-dimensional image of the surgical field; 2) patient side-cart, which sits beside the patient and consists of three instrument arms and one endoscope arm; 3) detachable instruments (endowrist instruments and intuitive masters), which simulate fine motor human movements. The hand movements of the surgeon's hands at the surgeon's console are translated into smaller ones by the robotic device and are acted out by the attached instruments; 4) three-dimensional vision system: the camera unit or endoscope arm. The main advantages of use of the robotic device are: 1) the precision of the instrument and improved dexterity due to the use of "wristed" instruments; 2) three-dimensional imaging, with improved ability to locate blood vessels, nerves and tissues; 3) the surgeon's console, which reduces fatigue accompanied with conventional laparoscopy surgery and allows for tremor-free manipulation. The main disadvantages of use of the robotic device are the costs including instrument costs (\$2.6 million in US dollars), cost per use (\$200 per use), the costs associated with training surgeons and operating room personnel, and the lack of tactile feedback, with the trade-off being increased visual feedback. **RESEARCH QUESTIONS:** For endometrial and cervical cancers, 1. What is the

effectiveness of the Da Vinci Surgical System vs. laparoscopy and laparotomy for women undergoing any hysterectomy for the surgical treatment and management of their endometrial and cervical cancers?2. What are the incremental costs of the Da Vinci Surgical System vs. laparoscopy and laparotomy for women undergoing any hysterectomy for the surgical treatment and management of their endometrial and cervical cancers?For prostate cancer, 3. What is the effectiveness of robotically-assisted radical prostatectomy using the Da Vinci Surgical System vs. laparoscopic radical prostatectomy and retropubic radical prostatectomy for the surgical treatment and management of prostate cancer?4. What are the incremental costs of robotically-assisted radical prostatectomy using the Da Vinci Surgical System vs. laparoscopic radical prostatectomy and retropubic radical prostatectomy for the surgical treatment and management of prostate cancer?

RESEARCH METHODS: LITERATURE SEARCH: SEARCH STRATEGY: A literature search was performed on May 12, 2010 using OVID MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, OVID EMBASE, Wiley Cochrane, CINAHL, Centre for Reviews and Dissemination/International Agency for Health Technology Assessment for studies published from January 1, 2000 until May 12, 2010. Abstracts were reviewed by a single reviewer and, for those studies meeting the eligibility criteria, full-text articles were obtained. Reference lists were also examined for any additional relevant studies not identified through the search. Articles with unknown eligibility were reviewed with a second clinical epidemiologist, then a group of epidemiologists until consensus was established. The quality of evidence was assessed as high, moderate, low or very low according to GRADE methodology.

INCLUSION CRITERIA: English language articles (January 1, 2000-May 12, 2010)Journal articles that report on the effectiveness or cost-effectiveness for the comparisons of interest using a primary data source (e.g. obtained in a clinical setting)Journal articles that report on the effectiveness or cost-effectiveness for the comparisons of interest using a secondary data source (e.g. hospital- or population-based registries)Study design and methods must be clearly describedHealth technology assessments, systematic reviews, randomized controlled trials, non-randomized controlled trials and/or cohort studies, case-case studies, regardless of sample size, cost-effectiveness studies

EXCLUSION CRITERIA: Duplicate publications (with the more recent publication on the same study population included)Non-English papersAnimal or in-vitro studiesCase reports or case series without a referent or comparison groupStudies on long-term survival which may be affected by treatmentStudies that do not examine the cancers (e.g. advanced disease) or outcomes of interest

OUTCOMES OF INTEREST: For endometrial and cervical cancers, Primary outcomes: Morbidity factors- Length of hospitalization- Number of complicationsPeri-operative factors- Operation time- Amount of blood loss- Number of conversions to laparotomyNumber of lymph nodes recoveredFor prostate cancer, Primary outcomes: Morbidity factors- Length of hospitalization- Amount of morphine use/painPeri-operative factors- Operation time- Amount of blood loss- Number of transfusions- Duration of catheterization- Number of complications- Number of anastomotic stricturesNumber of lymph nodes recoveredOncologic factors- Proportion of positive surgical marginsLong-term outcomes- Urinary continence- Erectile function

SUMMARY OF FINDINGS: Robotic use for gynecologic oncology compared to:**LAPAROTOMY:** benefits of robotic surgery in terms of shorter length of hospitalization and less blood loss. These results indicate clinical effectiveness in terms of reduced morbidity and safety, respectively, in the context of study design limitations.The beneficial effect of robotic surgery was shown in pooled analysis for complications, owing to increased sample size.More work is needed to clarify the role of complications in terms of safety, including improved study designs, analysis and measurement.**LAPAROSCOPY:** benefits of robotic surgery in terms of shorter length of hospitalization, less blood loss and fewer conversions to laparotomy likely owing to the technical difficulty of conventional laparoscopy, in the context of study design limitations.Clinical significance of significant findings for length of hospitalizations and blood loss is low.Fewer conversions to laparotomy indicate clinical effectiveness in terms of reduced morbidity.**Robotic use for urologic oncology, specifically prostate cancer, compared to:RETROPUBIC SURGERY:** benefits of robotic surgery in terms of shorter length of hospitalization and less blood loss/fewer individuals requiring transfusions. These results indicate clinical effectiveness in terms of reduced

morbidity and safety, respectively, in the context of study design limitations. There was a beneficial effect in terms of decreased positive surgical margins and erectile dysfunction. These results indicate clinical effectiveness in terms of improved cancer control and functional outcomes, respectively, in the context of study design limitations. Surgeon skill had an impact on cancer control and functional outcomes. The results for complications were inconsistent when measured as either total number of complications, pain management or anastomosis. (ABSTRACT TRUNCATED)

Hysterectomy Benign

- Comprehensive literature search Open GYN benign surgery versus Robotic Assisted GYN benign surgery versus Conventional laparoscopic or vaginal GYN benign surgery – 2010 to 2015
- Study types included: RCTs, prospective comparative studies, systematic reviews with meta-analysis, large (>5000 patients) real world retrospective database studies of established and high quality databases: PREMIERE, SEERS, NSQIP, NIS. HTAs
- This is a comprehensive literature search according to the above mentioned criteria. The search has been done with rigor, but we make no claim of being complete.

RCT (3)

Lonnerfors, C., et al. (2014). "A randomized trial comparing vaginal- and laparoscopic hysterectomy to robot-assisted hysterectomy." [Journal of Minimally Invasive Gynecology](#).

STUDY OBJECTIVE: To investigate the hospital cost and short-term clinical outcome of traditional minimally invasive versus robot-assisted hysterectomy in women primarily considered unavailable for vaginal surgery. DESIGN: This trial assesses the hospital cost and short-term clinical outcome in women randomly allocated to either robot-assisted- or traditional, minimally invasive hysterectomy in a 1:1 proportion with vaginal hysterectomy as a primary choice in the latter. All procedure-specific costs including cost of reinterventions were included, and robot cost was calculated either including procedure-specific equipment only, or incorporating seven years of depreciation and maintenance (300 cases/year). DESIGN: classification: Canadian Task Force I SETTING: University Hospital, Sweden from January 2010 and June 2013. PATIENTS: 122 women with a uterine size ≤ 16 weeks planned for minimally invasive hysterectomy for benign disease. INTERVENTIONS: Robot-assisted- or traditional, minimally invasive hysterectomy (vaginal- or laparoscopic hysterectomy). MEASUREMENTS AND MAIN RESULTS: All women underwent surgery according to their randomization with no demographic differences between groups. Vaginal hysterectomies were possible in 41% in the traditional minimally invasive group at a mean hospital cost of \$4579 compared to \$7059 for traditional, laparoscopic hysterectomy. This was reflected in a mean hospital cost of \$993 more per robot hysterectomy than traditional, minimally invasive hysterectomy when considering the robot as a preexisting investment. This increased by \$1607 when including investments and cost of maintenance. A per-protocol sub analysis comparing laparoscopy and robotics showed similar hospital cost when considering the robot as a preexisting investment (\$7059 versus \$7016). Robotics was associated with less blood-loss and fewer postoperative complications. CONCLUSION: A similar hospital cost can be reached for laparoscopy and robotics when the robot is considered a preexisting investment.

Robotic surgery is not, from a hospital cost perspective, advantageous for benign hysterectomies when a vaginal approach is feasible in a high proportion of patients.

Paraiso, M. F., et al. (2013). "A randomized trial comparing conventional and robotically assisted total laparoscopic hysterectomy." American Journal of Obstetrics and Gynecology.

OBJECTIVE: The purpose of this study was to compare operative time and intra- and postoperative complications between total laparoscopic hysterectomy and robotic-assisted total laparoscopic hysterectomy. STUDY DESIGN: This study was a blinded, prospective randomized controlled trial conducted at 2 institutions. Subjects consisted of women who planned laparoscopic hysterectomy for benign indications. Preoperative randomization to total laparoscopic hysterectomy or robotic-assisted total laparoscopic hysterectomy was stratified by surgeon and uterine size (> or <=12 weeks). Validated questionnaires, activity assessment scales, and visual analogue scales were administered at baseline and during follow-up evaluation. RESULTS: Sixty-two women gave consent and were enrolled and randomly assigned; 53 women underwent surgery (laparoscopic, 27 women; robot-assisted, 26 women). There were no demographic differences between groups. Compared with laparoscopic hysterectomy, total case time (skin incision to skin closure) was significantly longer in the robot-assisted group (mean difference, +77 minutes; 95% confidence interval, 33-121; $P < .001$] as was total operating room time (entry into operating room to exit; mean difference, +72 minutes; 95% confidence interval, 14-130; $P = .016$). Mean docking time was 6 +/- 4 minutes. There were no significant differences between groups in estimated blood loss, pre- and postoperative hematocrit change, and length of stay. There were very few complications, with no difference in individual complication types or total complications between groups. Postoperative pain and return to daily activities were no different between groups. CONCLUSION: Although laparoscopic and robotic-assisted hysterectomies are safe approaches to hysterectomy, robotic-assisted hysterectomy requires a significantly longer operative time.

Sarlos, D. K., L.; Stevanovic, N.; von Felten, S.; Schar, G. (2012). "Robotic compared with conventional laparoscopic hysterectomy: a randomized controlled trial." Obstetrics and Gynecology **120**(3): 604-611.

OBJECTIVE: : To compare surgical outcome and quality of life of robot-assisted laparoscopic hysterectomy with conventional laparoscopic hysterectomy. METHODS: : For this controlled clinical trial, patients with benign indications for hysterectomy were randomized to receive either a robotic (robotic group) or conventional laparoscopic hysterectomy (conventional group). The primary end point was total operating time; secondary end points were perioperative outcome, blood loss, and the change in quality of life. RESULTS: : Ninety-five patients out of 100 randomized patients completed the study. Patient age, body mass index, and uterus weight showed no significant differences between both groups. All results are given as mean (+/- standard deviation; median). Total operating time for the robotic group was significantly higher with 106 (+/-29; 103) compared with 75 (+/-21; 74) (conventional group) minutes. Blood loss, complications, analgesics use, and return to activity for both groups were comparable. The change in preoperative to postoperative quality-of-life index (quality of life measured on a linear scale from 0 to 100) was significantly higher in the robotic group, with 13 (+/-10; 13) compared with 5 (+/-14; 5) (conventional group). CONCLUSION: Robot-assisted laparoscopic hysterectomy and conventional laparoscopy compare well in most surgical aspects, but the robotic procedure is associated with longer operating times. Postoperative quality-of-life index was better; however, long-term, there was no difference. However, subjective postoperative parameters such as analgesic use and return to activity showed no significant difference between both groups. CLINICAL TRIAL REGISTRATION: ClinicalTrials.gov, www.clinicaltrials.gov, NCT00683293. LEVEL OF EVIDENCE:

Systematic Review and/or Meta-Analysis (3)

Gala, R. B., et al. (2014). "Systematic review of robotic surgery in gynecology: robotic techniques compared with laparoscopy and laparotomy." Journal of Minimally Invasive Gynecology **21**(3): 353-361.

The Society of Gynecologic Surgeons Systematic Review Group performed a systematic review of both randomized and observational studies to compare robotic vs nonrobotic surgical approaches (laparoscopic, abdominal, and vaginal) for treatment of both benign and malignant gynecologic indications to compare surgical and patient-centered outcomes, costs, and adverse events associated with the various surgical approaches. MEDLINE and the Cochrane Central Register of Controlled Trials were searched from inception to May 15, 2012, for English-language studies with terms related to robotic surgery and gynecology. Studies of any design that included at least 30 women who had undergone robotic-assisted laparoscopic gynecologic surgery were included for review. The literature yielded 1213 citations, of which 97 full-text articles were reviewed. Forty-four studies (30 comparative and 14 noncomparative) met eligibility criteria. Study data were extracted into structured electronic forms and reconciled by a second, independent reviewer. Our analysis revealed that, compared with open surgery, robotic surgery consistently confers shorter hospital stay. The proficiency plateau seems to be lower for robotic surgery than for conventional laparoscopy. Of the various gynecologic applications, there seems to be evidence that renders robotic techniques advantageous over traditional open surgery for management of endometrial cancer. However, insofar as superiority, conflicting data are obtained when comparing robotics vs laparoscopic techniques. Therefore, the specific method of minimally invasive surgery, whether conventional laparoscopy or robotic surgery, should be tailored to patient selection, surgeon ability, and equipment availability.

Scandola, M., et al. (2011). "Robot-Assisted Laparoscopic Hysterectomy vs Traditional Laparoscopic Hysterectomy: Five Metaanalyses." Journal of Minimally Invasive Gynecology **18**(6): 705-715.

To assess differences between laparoscopic hysterectomy performed with or without robot-assistance, we performed metaanalyses of 5 key indices strongly associated with societal and hospital costs, patient safety, and intervention quality. The 5 indexes included estimated blood loss (EBL), operative time, number of conversions to laparotomy, hospital length of stay (LOS), and number of postoperative complications. A search of PubMed, Medline, Embase, and Science citation index online databases yielded a total of 605 studies. After a systematic review, we proceeded with meta-analysis of 14 articles for EBL, with a summary effect of -0.61 (95% confidence interval [CI], -42.42 to 46.20); 20 for operative time, with a summary effect of 0.66 (95% CI, -15.72 to 17.04); 17 for LOS, with a summary effect of -0.43 (95% CI, -0.68 to -0.17); 15 for conversion to laparotomy (odds ratio, 0.50; 95% CI, 0.31 to 0.79 with a random model); and 14 for postoperative complications (odds ratio, 0.69; 95% CI, 0.43 to 1.09 with a random model). In conclusion, compared with traditional laparoscopic hysterectomy, robot-assisted laparoscopic hysterectomy was associated with shorter LOS and fewer postoperative complications and conversions to laparotomy; there were no differences in EBL and operative time. These results confirm that robot-assisted laparoscopy has less deleterious effect on hospital, society, and patient stress and leads to better intervention quality.

Tapper, A. M., et al. (2014). "A systematic review and cost analysis of robot-assisted hysterectomy in malignant and benign conditions." European Journal of Obstetrics Gynecology and Reproductive Biology.

In order to assess the effectiveness and costs of robot-assisted hysterectomy compared with conventional techniques we reviewed the literature separately for benign and malignant conditions, and conducted a cost analysis for different techniques of hysterectomy from a hospital economic database. Unlimited systematic literature search of Medline, Cochrane and CRD databases produced only two randomized trials, both for benign conditions. For the outcome assessment, data from two HTA reports, one systematic review, and 16 original articles were extracted and analyzed. Furthermore, one cost modelling and 13 original cost studies were analyzed. In malignant conditions, less blood loss, fewer complications and a shorter hospital

stay were considered as the main advantages of robot-assisted surgery, like any mini-invasive technique when compared to open surgery. There were no significant differences between the techniques regarding oncological outcomes. When compared to laparoscopic hysterectomy, the main benefit of robot-assistance was a shorter learning curve associated with fewer conversions but the length of robotic operation was often longer. In benign conditions, no clinically significant differences were reported and vaginal hysterectomy was considered the optimal choice when feasible. According to Finnish data, the costs of robot-assisted hysterectomies were 1.5-3 times higher than the costs of conventional techniques. In benign conditions the difference in cost was highest. Because of expensive disposable supplies, unit costs were high regardless of the annual number of robotic operations. Hence, in the current distribution of cost pattern, economical effectiveness cannot be markedly improved by increasing the volume of robotic surgery. © 2014 Elsevier Ireland Ltd. All rights reserved.

Prospective Comparative Studies (6)

de La Cruz, J. F., et al. (2014). "Vaginal versus Robotic Hysterectomy and Concomitant Pelvic Support Surgery: A Comparison of Postoperative Vaginal Length and Sexual Function." Journal of Minimally Invasive Gynecology.

STUDY OBJECTIVE: To compare the change from pre- to post-operative total vaginal length (TVL) in women who underwent either a vaginal hysterectomy (TVH) with uterosacral ligament suspension (USLS) or a robotic hysterectomy (RH) with colpopexy (SCP). Secondary objectives included comparing sexual function, pelvic floor function, and prolapse recurrence between routes of surgery. DESIGN: This was a retrospective cohort study. DESIGN: Classification: II-2 SETTING: This was conducted at one tertiary academic medical center over a two-year period. PATIENTS: Women who underwent either TVH/USLS or RH/SCP INTERVENTIONS: Baseline and postoperative POP-Q exams were recorded as well as postoperative validated questionnaires. Twenty-nine subjects were needed in each group to detect a 1.5 cm difference in TVL. MEASUREMENTS AND MAIN RESULTS: There were 38 TVH/USLS and 46 RH/SCP participants. Robotic hysterectomies were either total 28/46 (61%) or supracervical 18/46 (39%). Mean postoperative follow-up was 9.5+3.1 months. For the primary outcome, women in the TVH/USLS group had a decrease in TVL whereas women in the RH/SCP group had an increase in TVL (-0.6 +/- 1.0 cm vs. +0.5 +/- 0.8 cm, $p < .001$). Among sexually active women (55/84, 65.5%) there was no difference in postoperative sexual function between groups, based on PISQ-12 scores, with good sexual function in both groups (32.6 +/- 6.2 TVH/USLS vs. 35.1 +/- 7.3 RH/SCP, $p = .22$). While both groups demonstrated good postoperative apical support, the TVH/USLS group had a slightly lower mean C point compared to the RH/SCP group (-6.8 +/- 1.2 vs. -7.7 +/- 1.8, $p = .02$). Both groups demonstrated good postoperative pelvic floor function, with no difference in mean postoperative PFDI scores (42.2 +/- 45.4 vs. 52.7 +/- 46.6, $p = .44$). Recurrent prolapse (defined as any prolapse at or beyond the hymen) was not different between groups: 13.2% for TVH/USLS vs 6.5% for RH/SCP ($p = .46$). CONCLUSIONS: Vaginal length decreased after vaginal hysterectomy with pelvic support surgery as compared to robotic hysterectomy with pelvic support surgery, with no differences in postoperative sexual function or pelvic floor function between groups.

Eddib, A. J., N.; Aalto, M.; Hughes, S.; Eswar, A.; Erk, M.; Michalik, C.; Krovi, V.; Singhal, P. (2013). "An analysis of the impact of previous laparoscopic hysterectomy experience on the learning curve for robotic hysterectomy." Journal of Robotic Surgery: 1-5.

To analyze and compare the safety and perioperative outcomes of newly trained robotic surgeons with previous laparoscopic hysterectomy experience (TLH Exp) and those without previous laparoscopic hysterectomy experience (Non-TLH Exp). The purpose is to determine the effect of previous advanced laparoscopic skills on the performance in robotic assisted laparoscopic surgery. We will also compare the perioperative outcomes between the total laparoscopic hysterectomies (TLH), and robotic assisted laparoscopic hysterectomies (RALH) of a single

experienced (TLH Exp) robotic surgeon. The purpose is to determine benefits and/or risks, if any, of one approach over the other in the hands of an experienced laparoscopic surgeon. Prospective data were collected on the first consecutive series of RALH performed by (TLH Exp) and (Non-TLH Exp) surgeons, with perioperative outcomes and morbidity being evaluated. In addition, retrospective data were collected on a consecutive series of patients in a TLH group and compared with the outcomes in the robotic group for benign hysterectomies by the same surgeon. The parameters that were analyzed for associations with these two groups were estimated blood loss (EBL), Hb drop, length of hospital stay (LOS), procedure time, pain medication use, and complications. The (TLH Exp) group had 64 patients, and the (Non-TLH Exp) group had 72 patients. When comparing patients in the (TLH Exp) group with patients in (Non-TLH Exp) group, the mean age was 44 and 45 ($P = 0.8$), mean BMI was 27.7 and 29.5 kg/m² ($P = 0.2$), mean procedure time was 121 and 174 min ($P < 0.05$), mean console time was 70 and 119 min ($P < 0.05$), mean EBL was 64 and 84 ml ($P = 0.3$), with a Hb drop 1.7 and 1.33 ($P = 0.2$), uterine weight was 192 and 205 gms ($P = 0.7$), and length of stay was 1.07 and 1.33 days ($P = 0.2$), respectively. The (TLH Exp) surgeons had a lower OR, procedure and console time, but a higher hemoglobin drop, with no difference in EBL. There were no operative deaths, or conversions in either group. Morbidity occurred in two patients (3 %) in each group, with no statistically significant difference between the groups. In the (TLH Exp) group it included a blood transfusion and a readmission for a postoperative ileus. In the (Non-TLH Exp), the complications included a blood transfusion and a return to the OR for a vaginal cuff dehiscence. When comparing a single (TLH Exp) surgeon's own TLH versus RALH, there were 64 RALH and 49 TLH cases. There was a statistically significant difference in the mean procedure time 121.1 versus 88.8 min ($P < 0.05$), mean Hb drop 1.7 versus 2.3 ($P < 0.05$), and mean EBL 64.2 versus 158 ml ($P < 0.05$), respectively. The RALH group had a longer procedure time, but lower Hb drop, and less estimated blood loss. There were no operative deaths, or conversions in either group. Morbidity occurred in 2 patients in the robotic group, and included one blood transfusion, and one postoperative ileus. There were no complications noted in the laparoscopic hysterectomy group. Previous advanced laparoscopic skills appear to only significantly impact the length of the procedure, but not other variables. Robotic surgery may level the playing field between the basic and advanced laparoscopic surgeon for robotic assisted laparoscopic hysterectomy. In comparing the outcomes of RALH versus TLH by a single surgeon, the robotic assistance appeared to lengthen the procedure time, but reduce the amount of blood loss. Robotic surgery may offer a benefit of reduced blood loss at the expense of longer operating time. Similar studies including different surgeons are needed to validate these points, and thereby determine the risk-benefit balance between the two approaches for benign simple hysterectomies. © 2013 Springer-Verlag London.

Kilic, G. S. M., G.; Elbatany, A.; Radecki, C.; Phelps, J. Y.; Borahay, M. A. (2011). "Comparison of Perioperative Outcomes of Total Laparoscopic and Robotically Assisted Hysterectomy for Benign Pathology during Introduction of a Robotic Program." *Obstet Gynecol Int* **2011**: 683703.

Study Objective. Prospectively compare outcomes of robotically assisted and laparoscopic hysterectomy in the process of implementing a new robotic program. Design. Prospectively comparative observational nonrandomized study. Design Classification. II-1. Setting. Tertiary caregiver university hospital. Patients. Data collected consecutively 24 months, 34 patients underwent laparoscopic hysterectomy, 25 patients underwent robotic hysterectomy, and 11 patients underwent vaginal hysterectomy at our institution. Interventions. Outcomes of robotically assisted, laparoscopic, and vaginal complex hysterectomies performed by a single surgeon for noncancerous indications. Measurements and Main Results. Operative times were 208.3 +/- 59.01 minutes for laparoscopic, 286.2 +/- 82.87 minutes for robotic, and 163.5 +/- 61.89 minutes for vaginal ($P < .0001$). Estimated blood loss for patients undergoing laparoscopic surgery was 242.7 +/- 211.37 cc, 137.4 +/- 107.50 cc for robotic surgery, and 243.2 +/- 127.52 cc for vaginal surgery ($P = 0.05$). The mean length of stay ranged from 1.8 to 2.3 days for the 3 methods. Association was significant for uterine weight ($P = 0.0043$) among surgery methods.

Conclusion. Robotically assisted hysterectomy is feasible with low morbidity, a shorter hospital stay, and less blood loss. This suggests that robotic assistance facilitates a minimally invasive approach for patients with larger uterine size even during implementing a new robotic program.

Martinez-Maestre, M. A., et al. (2013). "Total Laparoscopic Hysterectomy With and Without Robotic Assistance: A Prospective Controlled Study." Surgical Innovation.

Background. Hysterectomies are very common, and most of them are still performed abdominally. The minimally invasive alternatives are perceived as difficult by gynecologists. Robotic assistance is thought to facilitate laparoscopic surgery. The aim of this study was to compare the surgical outcomes of robotic-assisted and conventional total laparoscopic hysterectomy. Methods. Patients, candidate to hysterectomy for benign indications, were allocated to either robotic or conventional laparoscopy in a quasi-randomized fashion. Patients were operated following a standardized surgical protocol. Main outcome measures were total surgical time, conversions to laparotomy, blood loss, hospital stay, and complications. Results. Fifty-one patients underwent robotic hysterectomy (mean age = 46.59 years) and 54 conventional laparoscopy (mean age = 50.02 years). The groups were homogeneous in body mass index and uterine weight. Robotic-assisted hysterectomies were significantly shorter (154.63 +/- 36.57 vs 185.65 +/- 42.98 minutes in the control group; P = .0001). Patients in the robotic group also had a significantly smaller reduction in hemoglobin (9.69% +/- 8.88% vs 15.29% +/- 8.39% in controls; P = .0012) and hematocrit (10.56% +/- 8.3% vs 14.89% +/- 8.11%; P = .008). No intraoperative conversions to laparotomy were required. Complication rate was low and similar in both groups. All patients were fully recovered at 1-month follow-up outpatient visit. Conclusions. Significantly lower operative times and blood loss indicate that robotic assistance can facilitate surgery already during the learning curve period. Nevertheless, proficiency can be reached in conventional laparoscopy through training, and the cost-effectiveness of robotic hysterectomy for benign conditions is yet to be confirmed.

Paek, J., et al. (2015). "Robotic single-site versus laparoendoscopic single-site hysterectomy: a propensity score matching study." Surgical Endoscopy.

BACKGROUND: The aim of this study was to compare the surgical outcomes of robotic single-site (RSS-H) and laparoendoscopic single-site total hysterectomy (LESS-H) and to evaluate the feasibility of RSS-H in patients with benign gynecologic disease. METHODS: The RSS-H was performed using the da Vinci single-site surgical platform, and the LESS-H using a single multi-channel port system at the umbilicus. Among 467 consecutive patients who had undergone total hysterectomy for benign gynecologic disease, surgical outcomes were compared between RSS-H group (n = 25) and LESS-H group (n = 442) after propensity score matching. RESULTS: All operations were completed robotically and laparoscopically without conversion to laparotomy, respectively. The RSS-H group had longer operating times and less operative bleeding compared to the LESS-H group. While the LESS-H showed 1.4 % of major complication rate, the RSS-H had no perioperative complication. Even after propensity score matching, the RSS-H still showed longer operating times (170.9 vs 94.1 min, p < 0.0001) and less operative bleeding (median estimated blood loss, 20 vs 50 ml, p = 0.009; mean hemoglobin drop, 1.6 vs 2.0 g/dl, p = 0.038) than the LESS-H. CONCLUSIONS: The RSS-H could be a feasible and safe procedure in appropriately selected patients with benign gynecologic disease, and further experience and technical refinements will continue to improve operative results. Prospective randomized trials will permit the evaluation of the potential benefits of the RSS surgery as a minimally invasive surgical approach.

Zechmeister, J. R., et al. (2014). "A Prospective Comparison of Post-Operative Pain and Quality of Life in Robotic Assisted versus Conventional Laparoscopic Gynecologic Surgery." American Journal of Obstetrics and Gynecology.

OBJECTIVE: We sought to compare robotic versus laparoscopic surgery in regards to patient reported post-operative pain and quality of life. STUDY DESIGN: This was a prospective study of

patients who presented for treatment of a new gynecologic disease requiring minimally invasive surgical intervention. All subjects were asked to take the validated Brief Pain Inventory-Short Form (BPI-SF) at 3 time points to assess pain and its effect on quality of life. Statistical analyses were performed using Pearson χ^2 and Student's *t* test. RESULTS: One hundred eleven were included in the analysis of which 56 patients underwent robotic assisted surgery and 55 patients underwent laparoscopic surgery. There was no difference in post-operative pain between conventional laparoscopy and robotic assisted surgery for gynecologic procedures. There was a statistically significant difference found at the delayed postoperative period when evaluating interference of sleep, favoring laparoscopy (ROB 2.0 v LSC 1.0; *p* 0.03). There were no differences found between the robotic and laparoscopic groups of patients receiving narcotics (56 vs 53, *p*=0.24, respectively), route of administration of narcotics (47 vs 45, *p*=1.0, respectively), or administration of non-steroidal anti-inflammatory medications (27 vs 21, *P*=0.33, respectively). CONCLUSIONS: Our results demonstrate no difference in post-operative pain between conventional laparoscopy and robotic assisted surgery for gynecologic procedures. Furthermore, pain did not appear to interfere consistently with any daily activity of living. Interference of sleep needs to be further evaluated after controlling for BSO.

Large Real World Database Analysis (7)

Cohen, S. L., et al. (2014). "Updated hysterectomy surveillance and factors associated with minimally invasive hysterectomy." JSLs: Journal of the Society of Laparoendoscopic Surgeons **18**(3).

BACKGROUND AND OBJECTIVES: The goal of this study is to obtain updated surveillance statistics for hysterectomy procedures in the United States and identify factors associated with undergoing a minimally invasive approach to hysterectomy. METHODS: A cross-sectional analysis of the 2009 United States Nationwide Inpatient Sample was performed. Subjects included all women aged 18 years or older who underwent hysterectomy of any type. Logistic regression and multivariate analyses were performed to assess the proportion of hysterectomies performed by various routes, as well as factors associated with undergoing minimally invasive surgery (laparoscopic, vaginal, or robotic). RESULTS: A total of 479 814 hysterectomies were performed in the United States in 2009, 86.6% of which were performed for benign indications. Among the hysterectomies performed for benign indications, 56% were completed abdominally, 20.4% were performed laparoscopically, 18.8% were performed vaginally, and 4.5% were performed with robotic assistance. Factors associated with decreased odds of a minimally invasive hysterectomy included the following: minority race (*P* < .0001), fibroids (*P* < .0001), concomitant adnexal surgery (*P* < .0001), self-pay (*P* = .01) or Medicaid as insurer (*P* < .0001), and increased severity of illness (*P* < .0001). Factors associated with increased odds of a minimally invasive hysterectomy included the following: age >50 years (*P* < .0001), prolapse or menstrual disorder (*P* < .0001), median household income of \$48 000-\$62 999 (*P* = .007) or \geq \$63 000 (*P* = .009), and location in the West (*P* = .02). A length of stay >1 day was most common in abdominal hysterectomy cases (96.1%), although total mean charges were highest for robotic cases (\$38 161). CONCLUSION: The US hysterectomy incidence in 2009 decreased from prior years' reports, with an increasing frequency of laparoscopic and robotic approaches. Racial and socioeconomic factors influenced hysterectomy mode.

Luciano, A. A., et al. (2015). "The impact of robotics on the mode of benign hysterectomy and clinical outcomes." International of Medical Robots and Computer Assisted Surgery.

BACKGROUND: The impact of robotics on benign hysterectomy surgical approach, clinical outcomes, and learning curve is still unclear. METHODS: Review of abdominal, vaginal, laparoscopic, or robotic cases in 156 US hospitals in the Premier Research Database. RESULTS: Of 289 875 hysterectomies, abdominal cases decreased from 2005-2010 (60-33%) and minimally invasive approaches increased (40-67%). Conversion rates were: 0.04% for vaginal, 2.5% for robotic, and 7.2% for laparoscopy (*P* < 0.001). Robotic surgery time was longest (3.4 h vs. 2.2 vaginal, 2.5 abdominal, 2.7 laparoscopy, *P* < 0.001). Robotic complication rate was lowest

(14.8% vs. 16.2% vaginal, 18.6% laparoscopy, 28.9% abdominal, $P < 0.001$). Hospital stay was longer following abdominal surgery (3.5 days vs. 1.8 robotic, 1.9 vaginal, 1.8 laparoscopy, $P < 0.001$). Robotic surgery times and conversion and complication rates improved with experience (2.8 h, 2%, and 13.9%, respectively), even with increasing complexity. CONCLUSIONS: Robotics was successfully incorporated without jeopardizing patient outcomes and increased the overall use of minimally invasive approaches. Copyright (c) 2015 John Wiley & Sons, Ltd.

Pasic, R. P. R., J. A.; Fang, H.; Ross, S.; Moore, M.; Gunnarsson, C. (2010). "Comparing Robot-Assisted with Conventional Laparoscopic Hysterectomy: Impact on Cost and Clinical Outcomes." Journal of Minimally Invasive Gynecology.

OBJECTIVE: To compare clinical and economic outcomes (hospital costs) in women undergoing laparoscopic hysterectomy performed with and without robotic assistance in inpatient and outpatient settings. METHODS: Using the Premier hospital database, we identified women >18 years of age with a record of minimally invasive hysterectomy performed in 2007 to 2008. Univariable and multivariable analyses examined the association between robot-assisted hysterectomy and adverse events, hospital costs, surgery time, and length of stay. RESULTS: Of 36 188 patient records analyzed from 358 hospitals, 95% ($n = 34\ 527$) of laparoscopic hysterectomies were performed without robotic assistance. Inpatient and outpatient settings did not differ substantively in frequency of adverse events. For cardiac, neurologic, wound, and vascular complications, frequencies were <1% for robot and non-robot procedures. In inpatient and outpatient settings alike, use of robotic assistance was consistently associated with statistically significant, higher per-patient average hospital costs. Inpatient procedures with and without robotic assistance cost \$9640 (95% confidence interval [CI] = \$9621, \$9659) versus \$6973 (95% CI = \$6959, \$6987), respectively. Outpatient procedures with and without robotic assistance cost \$7920 (95% CI = \$7898, \$7942) versus \$5949 (95% CI = \$5932, \$5966), respectively. Inpatient surgery times were significantly longer for robot-assisted procedures, 3.22 hours (95% CI = 3.21, 3.23) compared with non-robot procedures at 2.82 hours (95% CI = 2.81, 2.83). Similarly, outpatient surgery times with robot averaged 2.99 hours (95% CI = 2.98, 3.00) versus 2.46 hours (2.45, 2.47) for non-robot procedures. CONCLUSION: Our findings reveal little clinical differences in perioperative and postoperative events. This, coupled with the increased per-case hospital cost of the robot, suggests that further investigation is warranted when considering this technology for routine laparoscopic hysterectomies.

Rosero, E. B., et al. (2013). "Comparison of robotic and laparoscopic hysterectomy for benign gynecologic disease." Obstetrics and Gynecology **122**(4): 778-786.

OBJECTIVE: Use of robotically assisted hysterectomy for benign gynecologic conditions is increasing. Using the most recent, available nationwide data, we examined clinical outcomes, safety, and cost of robotic compared with laparoscopic hysterectomy. METHODS: Women undergoing robotic or laparoscopic hysterectomy for benign disease were identified from the United States 2009 and 2010 Nationwide Inpatient Sample. Propensity scores derived from a logistic regression model were used to assemble matched cohorts of patients undergoing robotic and laparoscopic hysterectomy. Differences in in-hospital complications, hospital length of stay, and hospital charges were assessed between the matched groups. RESULTS: Of the 804,551 hysterectomies for benign conditions performed in 2009 and 2010, 20.6% were laparoscopic and 5.1% robotically assisted. Among minimally invasive hysterectomies, the use of robotic hysterectomy increased from 9.5% to 13.6% ($P = .002$). In a propensity-matched analysis, the overall complication rates were similar between robotic and laparoscopic hysterectomy (8.80% compared with 8.85%, relative risk 0.99, 95% confidence interval [CI] 0.89-1.09, $P = .910$). There was a lower incidence of blood transfusions in robotic cases (2.1% compared with 3.1%; $P < .001$), but patients undergoing robotic hysterectomy were more likely to experience postoperative pneumonia (relative risk 2.2, 95% CI 1.24-3.78, $P = .005$). The median cost of hospital care was \$9,788 (interquartile range \$7,105-12,780) for robotic hysterectomy and \$7,299 (interquartile range \$5,650-9,583) for laparoscopic hysterectomy ($P < .001$). Hospital costs

were on average \$2,489 (95% CI \$2,313-2,664) higher for patients undergoing robotic hysterectomy. CONCLUSION: The use of robotic hysterectomy has increased. Perioperative outcomes are similar between laparoscopic and robotic hysterectomy, but robotic cases cost substantially more. LEVEL OF EVIDENCE: : II.

Wright, J. D. A., C. V.; Lewin, S. N.; Burke, W. M.; Lu, Y. S.; Neugut, A. I.; Herzog, T. J.; Hershman, D. L. (2013). "Robotically assisted vs laparoscopic hysterectomy among women with benign gynecologic disease." *JAMA - Journal of the American Medical Association* **309**(7): 689-698.

Importance: Although robotically assisted hysterectomy for benign gynecologic conditions has been reported, little is known about the incorporation of the procedure into practice, its complication profile, or its costs compared with other routes of hysterectomy. Objectives: To analyze the uptake of robotically assisted hysterectomy, to determine the association between use of robotic surgery and rates of abdominal and laparoscopic hysterectomy, and to compare the in-house complications of robotically assisted hysterectomy vs abdominal and laparoscopic procedures. Design, Setting, and Patients: Cohort study of 264 758 women who underwent hysterectomy for benign gynecologic disorders at 441 hospitals across the United States from 2007 to 2010. Main Outcome Measures: Uptake of and factors associated with utilization of robotically assisted hysterectomy. Complications, transfusion, reoperation, length of stay, death, and cost for women who underwent robotic hysterectomy compared with both abdominal and laparoscopic procedures were analyzed. Results: Use of robotically assisted hysterectomy increased from 0.5% in 2007 to 9.5% of all hysterectomies in 2010. During the same time period, laparoscopic hysterectomy rates increased from 24.3% to 30.5%. Three years after the first robotic procedure at hospitals where robotically assisted hysterectomy was performed, robotically assisted hysterectomy accounted for 22.4% of all hysterectomies. The rates of abdominal hysterectomy decreased both in hospitals where robotic-assisted hysterectomy was performed as well as in those where it was not performed. In a propensity score-matched analysis, the overall complication rates were similar for robotic-assisted and laparoscopic hysterectomy (5.5% vs 5.3%; relative risk [RR], 1.03; 95% CI, 0.86-1.24). Although patients who underwent a robotic-assisted hysterectomy were less likely to have a length of stay longer than 2 days (19.6% vs 24.9%; RR, 0.78, 95% CI, 0.67-0.92), transfusion requirements (1.4% vs 1.8%; RR, 0.80; 95% CI, 0.55-1.16) and the rate of discharge to a nursing facility (0.2% vs 0.3%; RR, 0.79; 95% CI, 0.35-1.76) were similar. Total costs associated with robotically assisted hysterectomy were \$2189 (95% CI, \$2030-\$2349) more per case than for laparoscopic hysterectomy. Conclusions and Relevance: Between 2007 and 2010, the use of robotically assisted hysterectomy for benign gynecologic disorders increased substantially. Robotically assisted and laparoscopic hysterectomy had similar morbidity profiles, but the use of robotic technology resulted in substantially more costs. ©2013 American Medical Association. All rights reserved.

