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ORIGINAL ARTICLE

Uterosacral vault suspension (USLS) at the time of hysterectomy: laparoscopic versus vaginal approach

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Abstract

Introduction and hypothesis To compare laparoscopic and vaginal approaches to uterosacral ligament vault suspension (USLS) by perioperative data, short-term complications, rates of successful concomitant adnexal surgery and procedural efficacy.

Methods Retrospective cohort of USLS procedures performed at the time of hysterectomy at a tertiary care center over a 3-year period. Patient demographics, surgical data, concomitant adnexal procedures and complications were abstracted from a surgical database and compared using parametric or non-parametric tests as appropriate. Validated questionnaires (POPDI-6, UDI-6, PROMIS) were used to collect information on recurrence and long-term complications. Patients were analyzed according to both intention-to-treat analysis based on the intended approach and the completed route of surgery to deal with intraoperative conversions.

Results Two hundred six patients met the criteria for inclusion; 152 underwent vaginal USLS (V-USLS) and 54 laparoscopic USLS (L-USLS). No statistically significant differences in mean case time, postoperative length of stay or perioperative infection were found. While no ureteric obstructions occurred in the L-USLS group, in the V-USLS group 14 (9%) obstructions occurred ($p = 0.023$). Postoperative urinary retention was higher with V-USLS (31% vs. 15%, $p = 0.024$). Rates of successfully completed adnexal surgery differed (56% vs. 98%, $p < 0.001$) in favor of L-USLS. Patient-reported symptomatic recurrence of prolapse was higher in the V-USLS group (41% vs. 24%, $p = 0.046$); despite this, re-treatment did not differ between the groups (0% vs. 7%, $p = 0.113$).

Conclusions Perioperative case time and complications did not differ between approaches. However, rates of completed adnexal surgery were significantly higher in the laparoscopic group, which could influence surgical decisions concerning approaches to prolapse surgery.

Keywords Pelvic organ prolapse · Uterosacral ligament suspension · Vaginal surgery · Laparoscopic surgery · Sacrospinous ligament suspension · Complications

Abbreviations

SSLF	Sacrospinous ligament fixation
US	Uterosacral
USLS	Uterosacral ligament suspension
V-USLS	Vaginal uterosacral ligament vault suspension
L-USLS	Laparoscopic uterosacral ligament vault suspension
UVS	Uterosacral vault suspension
MMC	Mayo-McCall culdoplasty
VH	Vaginal hysterectomy
OR	Operating room
BMI	Body mass index
ASA	American Society of Anaesthesiology
POP–Q	Pelvic organ prolapse quantification system
EBL	Estimated blood loss
LOS	Length of stay
POPDI-6	6-Question Pelvic Organ Prolapse Distress Inventory
NIH PROMIS SexFS	National Institutes of Health's Patient-Reported Outcomes Measurement Information System sexual function questionnaire
UDI-6	Urinary Distress Inventory
POP	Pelvic organ prolapse

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IQR	Interquartile range
UTI	Urinary tract infection
OBS	Opportunistic bilateral salpingectomy
EOC	Epithelial ovarian cancer
TVL	Total vaginal length

Introduction

A parous woman has a 40–60% risk of experiencing pelvic organ prolapse in her lifetime [1, 2]. More strikingly, 11% of women will undergo at least one surgery in their lifetime to correct prolapse [3].

Although anterior prolapse is most common, anterior and posterior repairs often fail if the vault is not well supported [4, 5]. The vaginal approach to vault support with native tissue repair is most common; 80–90% of procedures use this approach [6]. While mesh-based vault support (sacrocolpopexy) is considered the gold standard for the anatomic cure of vault prolapse, recent litigation over synthetic graft materials has refocused attention on the role of native tissue repair [7]. Therefore, it is clinically important to research the safety and efficacy of these procedures thoroughly given the paucity of existing data.

In a randomized controlled trial, Barber et al. compared two transvaginal approaches: (1) sacrospinous ligament fixation (SSLF) and (2) vaginal uterosacral ligament suspension (V-USLS) [8]. This study found neither surgery was superior and a surgical success rate of 59.2% with vaginal USLS (V-USLS) at 2 years and 38.5% at 5 years after the procedure [9]. The evidence for the laparoscopic approach to uterosacral ligament vault suspension (L-USLS) is less robust. Only retrospective reviews have been conducted, and few have compared L-USLS to V-USLS. All of these studies have been powered to detect a difference in complication rates; none of them were large enough to detect significant differences in success between the two different surgical routes.

Existing studies suggest that the success rate for the L-USLS is as good as the vaginal approach (V-USLS) [10–12] and that complication rates—specifically ureteric compromise—are lower for L-USLS [10–12]. Data directly comparing other characteristics such as total case time, postoperative failure of voiding protocols, length of stay and successful completion of concomitant procedures such as adnexal surgery between the approaches do not exist.

Our institution employs two approaches to uterosacral ligament vault suspension (USLS) at the time of vaginal hysterectomy: V-USLS and L-USLS. With a V-USLS approach the uterosacral ligaments are accessed through the vaginal cuff in a Mayo-McCall culdoplasty (MMC) fashion after completing a vaginal hysterectomy (VH) [13, 14]. In an L-USLS procedure, the uterosacral ligaments are secured laparoscopically prior to initiation of VH and then affixed to the distal aspect at the vaginal cuff at the hysterectomy's conclusion.

Given that both approaches are utilized by our group of surgeons, we designed a retrospective cohort study to directly compare techniques. We were most interested in how rates of concomitant adnexal surgery differ, given the increasing evidence that opportunistic salpingectomy reduces lifetime risk of ovarian cancer [15]. Several national and international societies (Society of Gynecologic Oncology of Canada, the American Congress of Obstetricians and Gynecologists, Society of Gynecologic Oncology and Kommission Ovar) have released expert opinion statements that recommend physicians discuss the risks and benefits of opportunistic salpingectomy with patients undergoing a hysterectomy or irreversible surgical contraception because of strong evidence for potential cancer prevention [16]. As such, our study's primary objective was to evaluate successful completion rates for adnexal surgery.

Secondary objectives were to compare perioperative data (surgical case time, postoperative length of stay) as well as short-term complications (blood loss, ureteric obstruction, bowel and bladder injury), rates of failing the institutional postoperative bladder protocol and conversion to other forms of vault suspension. Additionally, we sought to look at the effectiveness of each approach by evaluating patient-reported recurrence of prolapse via the 6-Question Pelvic Organ Prolapse Distress Inventory (POPDI) [17] score and long-term complications such as dyspareunia via the National Institutes of Health's Patient-Reported Outcomes Measurement Information System sexual function questionnaire (NIH PROMIS SexFS) [18].

Materials and methods

Setting

The study protocol was approved by the University of Calgary Conjoint Health Research Ethics Board (ethics ID REB16–2435). This is a retrospective cohort of all USLS procedures done at the time of vaginal hysterectomy over a 3-year window (January 2014–December 2016) performed in a large academic center in Calgary, Alberta, Canada. All surgeries were performed by one of three fellowship-trained urogynecologists. Our research team searched *The Division of Urogynecology* database of surgical cases for booking including both vaginal hysterectomy and planned concomitant uterosacral vault suspension.

Data collection

Demographic information was abstracted from the preoperative medical record: age, menopausal status, body mass index (BMI), American Society of Anesthesiology physical status classification system (ASA class), medical comorbidities, tobacco use, prior abdominal and gynecologic surgery, planned concomitant incontinence, adnexal and additional colporrhaphy procedures as well as the preoperative stage of uterine prolapse (defined as the score for "C" on POP-Q staging).

The chart for the surgical encounter was reviewed to confirm the final operative procedure and document conversion of the intended USLS to other forms of vault suspension (such as SSLF) as well as success of intended adnexal surgery. Length of surgery, estimated blood loss (EBL), surgical complications (such as ureteric obstruction, infections, visceral injuries and failing the institutional postoperative bladder protocol) along with length of stay (LOS) after surgery were also abstracted.

A senior Female Pelvic Medicine and Reconstructive Surgery fellow (SH) conducted telephone interviews to collect patient responses concerning procedural effectiveness and long-term complications using validated questionnaires. The 6-Item Pelvic Organ Prolapse Distress Inventory (POPDI-6) assessed patients for recurrence of prolapse; the Urinary Distress Inventory (UDI-6) assessed patients for latent stress urinary incontinence and overactive bladder; the NIH PROMIS Sexual Function and Satisfaction Questionnaire evaluated patients for dyspareunia. The majority of surveys were administered by phone, with a small portion returning a paper questionnaire. Consent to partake was implied by participants' completion of the surveys.

Patient-reported symptomatic recurrence of prolapse was defined as an affirmative answer to the first three questions of the POPDI-6 questionnaire: (1) Do you usually have a bulge or something falling out that you can see or feel in the vaginal area? (2) Do you usually experience pressure in the lower abdomen? or (3) Do you usually experience heaviness or dullness in the pelvic area? As per the POPDI scoring, all affirmative responses were self-scored on a 4-point scale specific to the question: "How much does this bother you?" Objective surgical success was defined by an absence of retreatment for prolapse by either surgery or pessary. This is similar to the composite outcome used in several trials for Pelvic Organ Prolapse (POP) repair [8].

Surgical techniques

All patients underwent vaginal hysterectomy. In addition to a native tissue vault suspension, concomitant surgeries were performed based on the surgeon's clinical impression. All planned surgeries for stress urinary incontinence were conducted by a retropubic midurethral sling.

Routine postoperative care followed, including a trial of void on postoperative day 1, except in the event of cystotomy and resultant planned prolonged catheterization.

The vaginal uterosacral suspension (V-USLS) used the modified Mayo-McCall culdoplasty technique: suspension sutures were placed through the uterosacral ligament on each side near the level of the ischial spine, and then each suture was attached to the vaginal apex. Traditional simultaneous obliteration of the posterior cul-de-sac or the Schull technique without this obliteration was at the intraoperative discretion of the surgeon and based on factors such as impression of vaginal caliber and/or presence of an identifiable enterocele sac.

In our laparoscopic approach (L-USLS), hysterectomy was performed laparoscopically to the completion of ligation of the uterine arteries. With the uterosacral ligaments still intact, a figure-eight suture was placed laparoscopically in the proximal/dorsal third of the uterosacral ligament on each side and tied down. Sutures were then rested on the ipsilateral pelvic side wall for future retrieval. The remainder of the procedure was performed vaginally with colpotomy being performed transvaginally. The distal uterosacral ligaments were clamped, cut and held vaginally. The USLS sutures previously placed laparoscopically were then swept down through the vagina and brought through the ipsilateral vaginal portion of the distal remnants of the uterosacral ligaments twice on each side using an open-eyed needle. No cul-de-sac obliteration occurred in L-USLS as each suture functioned independently rather than continuously from one USL to the other. Further intraoperative details are provided in Appendix 1.

In both techniques, after the USLS had been tied down, ureteral patency was assessed by cystoscopy. This was confirmed when pyridium-stained urine was visualized effluxing through the bilateral ureteric orifices.

Statistical power

A total of 206 cases were identified for inclusion, 54 L-USLS and 152 V-USLS. A power calculation was performed on the available rates of successful surgical treatment. To deem the L-USLS superior, our group agreed an improvement of 20% would be required to offset the increased burden of requiring a second assist and additional operating room equipment for the laparoscopic approach. Assuming a 61.5% success rate in the V-USLS group based on the OPTIMAL trial (8) and an 81.5% success rate in the L-USLS group, our sample had 80% power to detect a difference of this magnitude in success rates.

Data analysis

Uterosacral ligament suspensions were grouped by intention to treat, allocated to the approach in which the surgeon planned to perform USLS at the outset of surgery. Comparisons of only successfully completed V-USLS and

L-USLS surgeries as well as comparisons of successfully completed cases to conversions to other forms of vault suspension were planned as sensitivity analyses.

Categorical data are expressed as proportions and absolute numbers (n); chi-square approximate and Fisher's exact methods were used according to expected cell counts. Measured data were examined to determine if distributions were parametric or non-parametric, and centrality was expressed as mean ± standard deviation or median and interquartile range (IQR) as appropriate, with corresponding use of Mann-Whitney-U or non-paired t-tests. Data entry and management were carried out using EXCEL 16.11.1, and analyses were carried out using SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

Results

Two hundred six patients were identified for inclusion; 152 involved a planned V-USLS and 54 had a planned L-USLS. Figure 1 shows the flow of patients based on the planned surgical approach and performed technique.

Baseline patient characteristics are shown in Table 1. Patients with a planned V-USLS were slightly older than patients undergoing the laparoscopic approach (62.0 vs. 54.4 years, $p < 0.001$), but no differences existed in the following attributes: BMI, smoking status, ASA class or preoperative stage of prolapse by POP-Q.

Patient-reported and objective outcomes are shown in Table 2. Median follow-up period was 84.4 weeks for L-USLS and 107.4 weeks for V-USLS ($p = 0.002$). There was no difference in rates of response to the validated questionnaires based on the uterosacral suspension approach; the overall response rate was 80% (164/206). Patient-reported recurrent prolapse was higher for the V-USLS group (41% vs. 23.8%, $p = 0.046$). However, none of the L-USLS patients had surgical retreatment for prolapse compared with 7% ($n = 9$) of the V-USLS group ($p = 0.113$). POPDI-6 scores were higher in the planned vaginal USLS group than in the laparoscopic group. Proportions of women in each group reporting postoperative dyspareunia did not differ.

Perioperative data are shown in Table 3. Total case time was considered the total number of minutes from start of set-up to the patient leaving the operating room theater. During this window the sponge and instrument count occurred as well as tear-down and disposal of drapes and disposables. The decision was made to use this measurement of case time so that any additional nursing time incurred by set-up and take-down of laparoscopic equipment in addition to a vaginal set was captured. Overall mean case length differed by < 1 min: 127.0 min for V-USLS vs. 127.9 min for L-USLS ($p = 0.834$). Sensitivity analysis within the laparoscopic group showed that when an L-USLS could not be completed, conversion to a vaginal sacrospinous vault suspension did not significantly alter the case time (130.1 ± 22.8 min for a successful

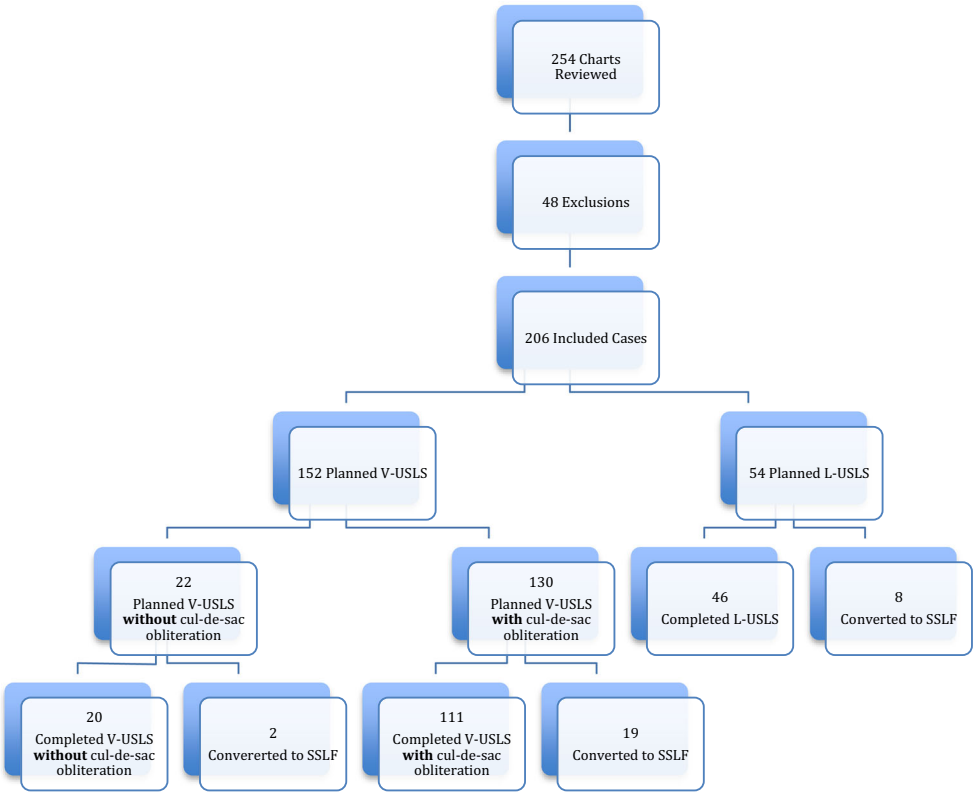

Fig. 1 Flow of patients based on the planned surgical approach and performed technique

Table 1 Baseline patient characteristics

Characteristics	Planned laparoscopy ($n = 54$)	Planned vaginal ($n = 152$)	p value
Age, mean (SD)	54.4 (12.0)	62.0 (10.6)	< 0.001
BMI, median (IQR)	27.3 (6.3)	26.9 (5.5)	0.643
ASA class			0.861
1	13 (24.1%)	41 (27.0%)	
2	36 (66.7%)	95 (62.5%)	
3	5 (9.3%)	16 (10.5%)	
Smoker, n (%)	7 (13.0%)	12 (7.9%)	0.280
Baseline POPQ Stage, n (%)			0.326
Stage 1	27 (52.9%)	69 (46.6%)	
Stage 2	21 (41.2%)	59 (39.9%)	
Stage 3 and 4	3 (5.9%)	20 (13.5%)	
Preop POP-Q C score, median (IQR)	−2 (3)	−1 (3)	0.020

L-USLS versus 115.4 ± 26.7 min if there was a conversion to SSLF, $p = 0.106$) In contrast, examination of the V-USLS group showed that case length was extended by an average of 22 min ($p < 0.001$) if a conversion to SSLF was required (124 ± 28.3 min for V-USLS vs. 145.6 ± 27.0 min for conversion to SSLF).

Rates of conversion from uterosacral vault suspension to sacrospinous vault suspension did not differ between approaches (L-USLS, 15% vs. V-USLS, 14%, $p = 0.856$). Of the eight laparoscopic conversions, six cases were converted because the surgeon did not deem the quality of the uterosacral ligament to be sufficient for suspension. Two cases were converted because the patient could not tolerate the degree of Trendelenburg required to retract redundant small bowel out of the pelvis. In these cases, a retroperitoneal approach to the sacrospinous ligament was utilized for suspension to limit risk of bowel entrapment in suspension sutures. In the vaginal group, the majority of conversions occurred because of ureteric kinking ($n = 14$). In these cases, removal of the V-USLS sutures universally resolved the compromise. The other conversions in the V-USLS group occurred because the degree of apical support at the end of the V-USLS was not satisfactory to the surgeon, leading the surgeon to employ SSLF to improve the degree of apical support. Ninety-two percent (140) of women consented to opportunistic adnexectomy at the time of prolapse repair in the planned vaginal approach group versus 98% (53) in the planned laparoscopic group. Of these women, rates of successful completion of adnexal surgery differed between the two approaches (56% vs. 98%, $p < 0.001$) favoring the laparoscopic approach. The majority of patients undergoing either approach for vault suspension also had a concomitant anterior and posterior repair.

In both approaches, blood loss and the need for transfusion were similar. There were no ureteric obstructions in the laparoscopic approach, but there were 14 (9%) ureteric obstructions in the vaginal approach ($p = 0.023$).

Table 2 Patient outcomes

Variable	Planned laparoscopy (n = 54)	Planned vaginal (n = 152)	Difference‡ (95% confidence interval)	p value
Symptomatic recurrence prolapse, n (%)	10 (23.8)	50 (41.0)	−17.2% (−32.7% to −1.6%)	0.046
POPDI-6 score, median (IQR)	(8.3)	4.2 (16.7)	−26.0 (−48.0 to −8.7)	0.022
ANY retreatment for recurrent prolapse, n (%)	3 (7.1%)	17 (13.9%)	−6.8% (−16.7% to 3.1%)	0.246
Pessary for recurrent prolapse, n (%)	3 (7.1%)	7 (5.7%)	1.4% (−7.4% to 10.2%)	0.717*
Repeat surgery for recurrent prolapse, n (%)	0 (0.0)	9 (7.4)	−7.4% (−12.0% to 2.7%)	0.113*
Dyspareunia, n (%)	12/30 (40)	24/60 (40)	0.0% (−21.5% to 21.5%)	> 0.999
Difficulty with sexual activity†	12 (40.0)	23 (38.3)	1.7% (−19.8% to 23.1%)	0.879
Stopped sexual activity†	5 (16.7)	14 (23.3)	−6.7% (−23.8% to 10.4%)	0.465
Treatment for painful intercourse	2 (6.7)	7 (11.7)	−5.0% (−17.1% to 7.1%)	0.712*

*Fisher's exact test

‡ Risk difference for proportions, difference in mean for length of surgery, and Hodges-Lehmann median difference for EBL and POPDI-6

† Of those who were in a relationship that could involve sexual activity, a response of rarely, sometimes, often or always

Table 3 Perioperative outcomes

Variable	Planned laparoscopy (n = 54)	Planned vaginal (n = 152)	Difference‡ (95% confidence interval)	p value
Concomitant surgery				
MUS	7 (13%)	26 (17%)	−4.1% (−14.9% to 6.6%)	0.476
Anterior or posterior repair	51 (94%)	142 (93%)	1.0% (−6.3% to 8.3%)	> 0.999
Anesthesia				
GA	54 (100)	136 (89.3)	n/a	n/a**
Spinal	N/A	15 (10)		
Failed spinal	N/A	1 (0.7)		
Length of surgery (min), mean (SD)	127.9 (23.7)	127.0 (29.0)	0.9 (−7.7 to 9.6)	0.834
EBL (ml), median (IQR)	200 (150)	200 (150)	−50 (−50 to 0)	0.051
Transfusion, n (%)	1 (1.9)	4 (2.6)	−0.8% (−5.2% to 3.6%)	> 0.999*
Ureteric obstruction, n (%)	0 (0.0)	14 (9.2)	−9.2% (−13.8% to −4.6%)	0.023*
Bladder injury, n (%)	0 (0.0)	0 (0.0)	n/a	n/a
Bowel injury, n (%)	0 (0.0)	1 (0.7)	−0.7% (−1.9% to 0.6%)	> 0.999*
Vascular injury, n (%)	0 (0.0)	0 (0.0)	n/a	n/a
Infection, n (%)	13 (24.1)	23 (15.1)	8.9% (−3.8% to 21.7%)	0.137
UTI	11	20		
Bacterial vaginosis	0	2		
Cuff cellulitis	2	0		
Pelvic abscess	0	1		
Adenexectomy successful, n (%)	52 (98.1)	78 (55.7)	42.4% (33.4% to 51.4%)	< 0.001
Intraop conversion to SSLF, n (%)	8 (14.8)	21 (13.8)	1.0% (−9.9% to 11.9%)	0.856
Failing institutional postop bladder protocol, n (%)	8 (14.8)	46 (30.7)	−15.9% (−27.9% to −3.8%)	0.024
Length of stay in hospital (days), median (IQR)	2 (1)	2 (1)	0 (0 to 0)	0.743

*Fisher's exact test

‡ Risk difference for proportions, difference in mean for length of surgery, and Hodges-Lehmann median difference for EBL and POPDI-6

**Statistical tests not appropriate given laparoscopic surgery requires general anesthetic

Composite infection rates including urinary tract infection, abscess, cuff cellulitis and vaginitis were higher with L-USLS (24% vs. 15%, $p = 0.137$). Urinary retention, defined as the inability to pass the postoperative voiding protocol spontaneously, resulting in the patient needing to learn to self-catheterize while in hospital, was higher with V-USLS (31% vs. 15%, $p = 0.024$). This was confirmed with a sensitivity analysis comparing only successfully completed L-USLS cases with successfully completed V-USLS, as the difference in urinary retention strengthened (L-USLS, 10.9% vs. V-USLS, 32.3%, $p < 0.005$). Despite this, length of stay (LOS) after surgery did not differ between groups, with the median LOS being 2 (1) days for both groups.

Discussion

This is the largest retrospective study to compare uterosacral ligament vault suspension techniques concomitantly performed at the time of hysterectomy. Our results suggest patient-reported recurrence of prolapse may be lower with L-USLS, with the added benefit of lower rates of ureteric compromise and urinary retention. This is achieved without increasing the total case time or postoperative length of stay.

Our findings regarding intraoperative complications reinforced what has been described in the literature. We found statistically lower rates of intraoperative ureteric compromise by kinking laparoscopically. Rardin et al. published a retrospective review in 2009 that showed nonsignificant trends toward fewer ureteric injuries from the laparoscopic procedure [10]. Two larger studies published since Rardin's article (Barbier 2015 and Turner 2016) were powered to evaluate complication rates and, more specifically, ureteral compromise [11, 12]. Rardin, Barbier, and Turner reported four, 6, and 7 ureteric kinking events respectively; all but one of these compromises occurred in the vaginal groups [12–14]. Unger et al. undertook the largest retrospective series examining V-USLS ($n = 983$) and found a rate of 4.5%. While our rates of intraoperative ureteric kinking may seem much higher than the rate described by Unger, the lower limit of our confidence interval (95% CI 5.1%–15.0%) is close to their estimate, and it is possible that the prevalence of this complication is overestimated in our data set because of its smaller sample size.

For visceral damage with the vaginal approach (V-USLS), a large systematic review and metaanalysis by Margulies found one cystotomy (0.1%) and two bowel injuries (0.02%) [19]; a Cleveland Clinic series had ten (1%) cystotomies and one bowel injury (0.1%) [20]. No visceral or vascular injuries occurred with the laparoscopic approach in the aforementioned studies. Our results are in keeping with the literature given our sole visceral injury being a bowel injury with a vaginal approach.

Blood loss was comparable between approaches, and our transfusion rates were comparable to previous studies. In both Barbier's and Turner's reviews, there was a non-significant trend toward increased UTIs postoperatively in the V-USLS group [11, 12]. Our overall composite of infectious complications statistically favored V-USLS, but when each component infection type was compared individually no significant differences existed between the groups. The most common infectious complication in both groups was a urinary tract infection defined by patient-reported symptomatology with confirmatory laboratory culture.

Our rates suggest L-USLS have significantly lower rates of failing institutional postoperative bladder protocol compared with V-USLS. This agrees with results by Rardin et al. who also reported a trend toward lower rates of postoperative urinary retention with the laparoscopic approach. Despite this doubled rate of urinary retention, the length of stay in hospital was not different between the approaches. Other studies such as the OPTIMAL trial have shown longer postoperative stays with V-USLS (upwards of 2.4 days [8]), which may be due to a longer trial of void and time needed to educate patients on self-intermittent catheterization or indwelling Foley catheter care.

Our trial showed the total operative room time was similar between the two approaches. Work by Turner et al. found a very small increase in operative time for a laparoscopic approach (L-USLS 190 min vs. V-USLS 172 min, $p = 0.03$) [14], although differences of < 15 min have been deemed "clinically inconsequential with regard to the performance status of the patient" [21]. One of the more striking findings of our study is that the total operative time for the intended laparoscopic approach did not differ for successfully completed L-USLS vs. those that were converted to SSLF. This differs from the V-USLS group where conversion incurred an average additional 22 min. This is likely due to the natures of conversions being different for L-USLS vs. V-USLS. In the laparoscopic group conversions occurred because the surgeon deemed the uterosacral ligament too weak to provide adequate support, while in the V-USLS group the majority of conversions were due to ureteric compression and a smaller portion was converted solely for failure of apical support. The fact that case time increases in V-USLS conversions suggests V-USLS may actually be more disruptive to OR planning because of the potential increased variability in case times.

One of the perceived benefits of the laparoscopic approach includes the magnified view of the operative field, which can enable easier dissection and enhanced identification of pelvic floor-supporting defects. This enhanced view allows for more precise suture placement and improved tissue capture. Laparoscopy also provides better visualization of vital structures; therefore, it has the capacity to help limit injuries—specifically to the ureter—which could be further protected by a prophylactic ureterolysis prior to the suspension procedure. In our cohort we did not routinely utilize ureterolysis and only performed prophylactic ureterolysis in one case where the distal aspect of the ureter was found to be in exceptionally close proximity to the uterosacral ligaments bilaterally. The laparoscopic approach's benefit to ureteric injury prevention was clearly demonstrated in our study, and it also supports previously published studies that report negligible ureteric injury rates [10–12].

Concerning effectiveness parameters, the symptomatic recurrence based on a composite outcome of subjective reporting from POPDI-6 or retreatment was higher in the V-USLS group than in the L-USLS group. Barbier et al. (2015) reported on 208 women (60 underwent V-USLS compared with 148 by L-USLS) [11]. Despite no difference in POP-Q stage between the groups postoperatively, recurrent prolapse (defined as prolapse at—or beyond—the hymen or retreatment with either surgery or pessary) was higher in the vaginal group (15% compared with 4% in the laparoscopic group). It should be kept in mind though that just like our study, Barbier did not find a difference in reoperation rates [11].

One of the striking findings of our study is the large difference in successful completion of intended adnexal surgery. These results are echoed by Turner who found a higher rate of salpingo-oophorectomy at the time of L-USLS [12]. Previous work has shown that retaining fallopian tubes at the time of hysterectomy, or failing to successfully remove them, increases the risk of subsequent reoperation for tubal pathology [22]. Additionally, opportunistic bilateral salpingectomy (OBS) has been associated with a 40–65% decrease in the incidence of epithelial ovarian cancer (EOC) when performed at the time of benign hysterectomy in patients at population-level risk for EOC [23]. Accordingly, OBS is increasingly viewed as a preventative strategy for ovarian and tubal cancers. As such, many organizations are in discussions concerning whether salpingectomy at the time of hysterectomy should be considered mandatory—or, for that matter, if failure to perform OBS should be considered negligent. In keeping with current guidelines, our view is that with the increasing interest in opportunistic salpingectomy in premenopausal women and salpingo-oophorectomy in postmenopausal women discussion regarding prophylactic adnexal surgery is what should be considered mandatory and that it is important for the surgeon to use an approach that gives the highest probability of successful completion of the adnexal surgery if the patient requests a prophylactic procedure. Our

study, therefore, would promote a laparoscopic approach with respect to management of the adnexa.

Limitations of our study include the retrospective nature and variable lengths of follow-up. The questionnaire response rate was high in both groups, but the possibility of selection bias due to non-response does exist. We would hypothesize the direction of this bias to be an overestimation of patient-reported outcomes as our impression is that patients with no outstanding concerns are less likely to answer questionnaires. Those with active concerns are often still engaged as patients of our clinic, and those with small nagging concerns were very open to discussing them when the urogynecology fellow made contact. While the limitations of our study mean that the level of evidence provided is inferior to that provided by prospective studies, they do contribute a valuable contribution to the existing literature as the information can be used to power future clinical trials. Use of patient-reported outcomes (PROs) in clinical research have strengths and limitations. Discordance can occur between physical examination findings and patient report of prolapse. This can occur in either direction, with anatomic "failure" occurring despite a successful outcome by PRO or patient-reported "failure" with a satisfactory examination. However, PROs are patient centered, allowing the individual to define whether surgery has "cured" them rather than a surgeon defining this outcome based on pelvic examination alone. Use of PROs as an outcome gives a sense of the patient's experience with their treatment [24] and remains a valuable tool in research given that the ultimate goal of clinical practice is not to create the most anatomically perfect POP repair, but rather to ensure that the patient's needs have been met by the surgical intervention.

As the gold standard for native tissue prolapse surgery has yet to be determined, comparative analyses such as ours are important to build the body of literature regarding success and complication rates. Our study represents an important step in determining whether laparoscopic uterosacral suspension (L-USLS) is superior to the vaginal approach (V-USLS). This information will help plan a prospective surgical trial to re-evaluate the operative time, length of stay, and—importantly— determine complication and recurrence rates. Furthermore, this trial will evaluate the importance of opportunistic adnexal surgery for women undergoing pelvic reconstructive surgery. The balance of these findings will dictate which approach is truly superior.

Conclusions

Laparoscopic uterosacral vault suspension offered higher rates of patient-reported cure, lower rates of intraoperative ureteric kinking, lower rates of failing institutional postoperative bladder protocol and higher rates of successful concomitant adnexal surgery without incurring longer total operative case times or higher rates of vascular or visceral injury. These differences may influence surgical decision-making in terms of which approach to choose when performing uterosacral vault suspension at the time of hysterectomy.

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Compliance with ethical standards

Conflicts of interest Erin Brennand has received grant-in-aid funding for investigator-initiated research from Boston Scientific and Contura International. Colin Birch has accepted paid travel expenses and speaker honoraria from Boston Scientific. Sara Houlihan, Shunaha Kim-Fine and Selphee Tang have no declarations.

Appendix 1: Description of laparoscopic USLS procedure

After the anesthetist induces general anesthesia, the patient is placed in the low-dorsal lithotomy position. Subsequently, the surgical team insufflates with CO_2 using a Veress needle; then, the surgeon places the laparoscopic trocars. Specifically, a 10-mm trocar—for a 30-degree 10-mm laparoscope—is placed at the umbilicus. On the operator's side, a 10-mm port is established in the left lower quadrant (lateral to the inferior epigastric vessel), and an upper 5-mm port is placed lateral to the rectus abdominis muscles at about the level of the umbilicus (5-mm periumbilical left-sided port). A 5-mm port is established on the assistant's side (again lateral to the inferior epigastric vessel).

The patient is then placed in the Trendelenburg position, and the bowel is swept out of the pelvis. Depending on the proximity of the ureters to the distal portion of the uterosacrals, a unilateral or bilateral ureterolysis may be undertaken.

The laparoscopic portion of the hysterectomy is then completed in the usual fashion. The IP ligaments are clamped, cauterized and transected bilaterally; following these components of the procedure, the round ligaments are clamped, cauterized and transected. The broad ligament is then opened, allowing skeletonization of the uterine artery bilaterally and the creation of an anterior bladder flap. The uterine arteries are then coagulated with bipolar cautery. After the uterus has been devitalized—but before colpotomy—the surgical team places the uterosacral suspension sutures.

Upward pressure is placed on the uterine manipulator to help identify the uterosacral ligaments. Care is also taken to identify the course of the ureters that are anterolateral to the uterosacral ligaments. A figure-eight suture of 0 prolene on an MO-6 needle is then introduced through the 10-mm port and placed in the caudal distal aspect on each side. The suture is tied extracorporeally, and is held through the ipsilateral lower quadrant ports (photos 1 and 2).

Attention is then turned to the vaginal portion of the procedure. A vaginal colpotomy is performed. The remaining uterosacral ligaments are clamped, cut, Heaney tied and then held. The cardinal ligaments are clamped, cut and suture ligated sequentially using 0 vicryl. Finally, the previously cauterized uterine arteries are clamped, cut and suture ligated. The uterus, tubes and ovaries are delivered.

The Prolene sutures previously placed laparoscopically are then swept down through the vagina, and they are brought through the ipsilateral vaginal portion of the distal remnants of the uterosacral ligaments twice on each side using an open-eyed needle (photo 3).

The vagina is then closed in running-locking fashion horizontally.

An anterior repair can then be undertaken as needed.

The vaginal vault is then elevated using a Babcock, which allows the prolene uterosacral suspension sutures to be tied down without tension. Cystoscopy is then performed.

At the end of the procedure, the surgical team can re-insufflate the abdomen to evaluate the USLS. If suture bridges are noted, an additional laparoscopic suture is placed near the prior uterosacral sutures to close this gap. The original suture may or may not be cut and removed depending on the size of the any residual loop and the surgeon's impression as to whether it will pose a risk to the small bowel in the future.

Photo 1

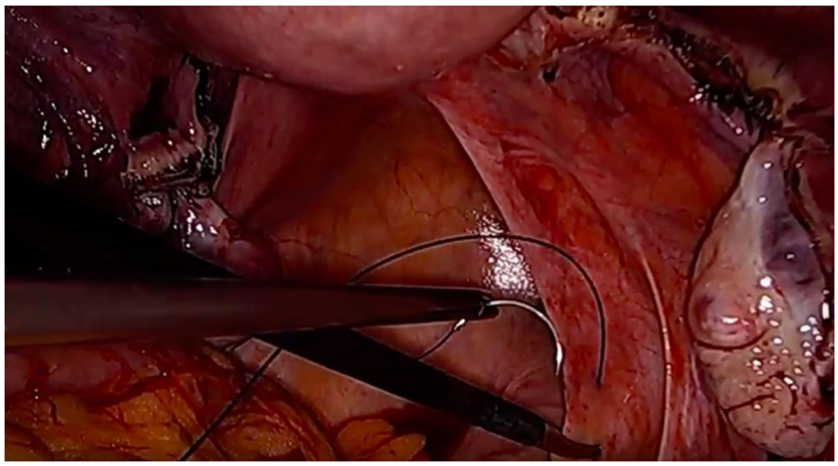


Photo 2

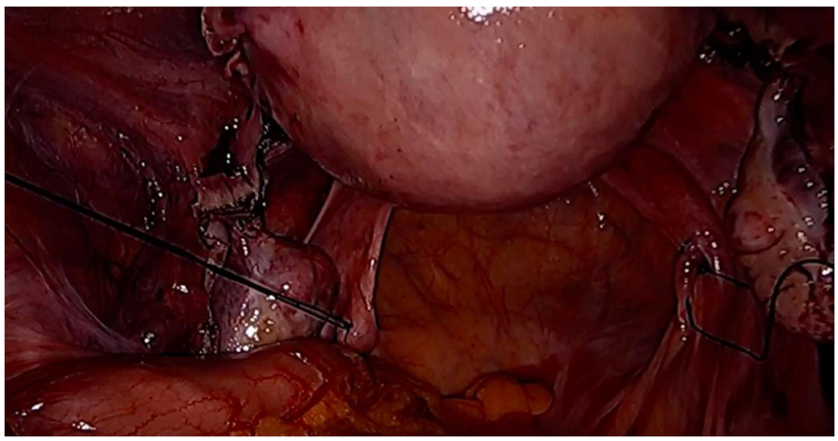
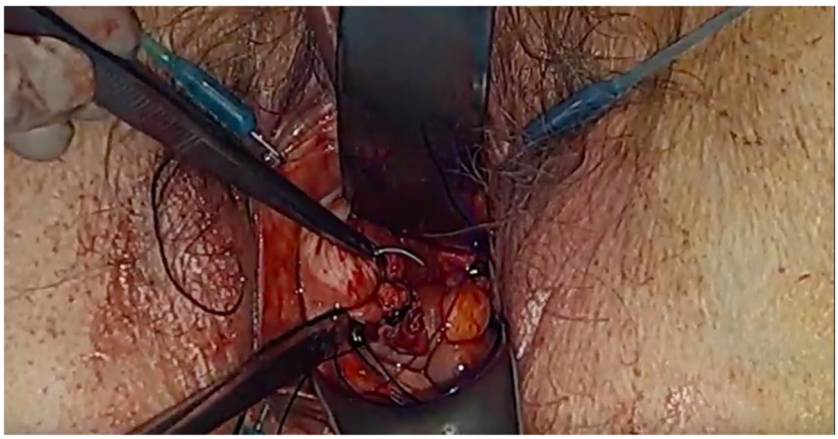


Photo 3



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