The Impact of Minimally Invasive Surgery on Major Iatrogenic Ureteral Injury and Subsequent Ureteral Repair During Hysterectomy: A National Analysis of Risk Factors and Outcomes

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OBJECTIVE To identify risk factors for ureteral injury during hysterectomy and to assess outcomes of concurrent minimally invasive vs converted to open repairs.

METHODS We queried the American College of Surgeons-National Surgical Quality Improvement Program database between 2005 and 2013 to identify abdominal hysterectomy (AH), minimally invasive hysterectomy (MIH), or vaginal hysterectomy. Ureteral injury was identified based on intraoperative or delayed management. Multivariate logistic regression was performed to assess the effect of hysterectomy approach on risk of ureteral injury while controlling for covariates. For patients with ureteral injury during MIH, we compared 30-day outcomes following minimally invasive vs converted open repairs.

RESULTS There were 302 iatrogenic ureteral injuries from 96,538 hysterectomies, with 0.18%, 0.48%, and 0.04% from AH, MIH, and vaginal hysterectomy, respectively. Patients who underwent MIH were younger and had decreased comorbidities compared to patients who underwent AH (all $P < .001$). MIH resulted in lower overall complications (6.6% vs 14.8%, $P < .001$) but higher ureteral injury rate (0.48% vs 0.18%, $P < .001$) compared to AH. On multivariate analysis, the minimally invasive approach was associated with increased risk of ureteral injury (odds ratio 4.2, $P < .001$). Patients undergoing minimally invasive ureteral repairs (89%) during MIH had shorter operating room time and length of stay but similar overall perioperative complications compared to those with converted open repairs (11%).

CONCLUSION Using a large national series, we show that the minimally invasive approach for hysterectomy is an independent risk factor for iatrogenic ureteral injuries. During MIH, concurrent minimally invasive ureteral repairs resulted in comparable 30-day outcomes compared to converted to open repairs. UROLOGY ■■: ■■–■■, 2016. © 2016 Elsevier Inc.

Iatrogenic ureteral injuries during pelvic surgery are uncommon but challenging complications. Whereas minimally invasive surgery has been associated with improved convalescence for many procedures, the advent of laparoscopic and robotic-assisted approaches for hysterectomy has had an unclear impact on the incidence of ureteral injuries.[1] Abdominal hysterectomy (AH) was the predominant technique to manage uterine lesions until the introduction of laparoscopic hysterectomy (LH) in 1992.[2] A historic series from 1997 revealed that the rate of ureteral injury from LH was 1.3%, whereas a more recent study in 2011 demonstrated a reduced rate of 0.3%.[3,4]

Intraoperative repairs of major iatrogenic distal ureteral injuries are most commonly open ureteroneocystostomy or ureteroureterostomy, depending on level and degree of injury.[5,6] Recent case reports have demonstrated feasibility of continued laparoscopic or robotic-assisted repair for ureteral injuries that are identified during minimally invasive hysterectomy (MIH), rather than conversion to open laparotomy.[7] However, given limited available evidence, the American Urological Association and European Association of Urology guidelines for iatrogenic trauma do not make any recommendations regarding the optimal approach of repair of major injuries during MIH.[8,9]

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The aims of our study were twofold: to utilize a national database to examine risk factors of major iatrogenic ureteral injury during AH vs MIH and to compare 30-day outcomes based on approach of intraoperative repair for ureteral injury during MIH.

METHODS

Data Source and Population

We queried the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) Participant User Files from 2005 to 2013 to identify adult patients (≥18 years) who underwent hysterectomy by gynecologists. The validated ACS-NSQIP database is maintained by certified surgical reviewers trained by the ACS and has been shown to have improved accuracy over other traditional data sources.[10,11] Institutional review board exemption was not required because no patient, physician, or hospital identifiers were examined.

Procedures were categorized based on Current Procedural Terminology (CPT) codes (Supplementary Table S1) as abdominal hysterectomy (AH), MIH, or vaginal hysterectomy (VH). MIH included laparoscopic and robotic-assisted hysterectomies. VH was included to assess ureteral injury rates across all approaches of hysterectomy. For some approaches, surgical approach was further subclassified as total (standard), radical, or supracervical hysterectomy. For MIH, laparoscopic-assisted vaginal hysterectomy, laparoscopic supracervical hysterectomy, and weight of the uterus (less or greater than 250 g) were designated. Patients undergoing AH with concurrent laparoscopic codes were considered laparoscopic cases. CPT codes for operations removing major pelvic tumors (exenterations, debulking, or recurrent cancer) were excluded. Institutional review board approval was not required due to lack of identifiable patient data. Demographic data, comorbidities, laboratory values, and 30-day outcomes including complications, readmission, and reoperation were available for analysis. Weight loss was defined at loss of >10 pounds within 6 months of surgery in this database.

Outcomes

Major ureteral injuries were defined as those resulting in immediate intraoperative management (repair and percutaneous nephrostomies [PCNs]) or delayed ureteral repair, stent, or PCN. Major ureteral injuries were identified based on ureteral repair CPT codes designated as other or concurrent procedures in NSQIP (Supplementary Table S2). Minor ureteral injuries managed with immediate ureteral stenting were unable to be assessed because NSQIP variables cannot differentiate routine preoperative stent placement vs stent placement for minor ureteral injuries.

Thirty-day postoperative outcomes included infectious (urinary tract infection [UTI], sepsis/septic shock), wound, renal, thromboembolic, cardiac, pulmonary, and neurologic complications, as well as need for transfusion, reoperation, readmission, and death rates.

Statistical Analysis

Statistical analysis was performed using Stata, version 13.0 (College Station, TX). Continuous variables were presented as median and interquartile range and were compared using the Mann-Whitney *U* test. Categorical variables were presented as whole numbers and percentages and were compared using the Pearson chi-square test. Multivariable logistic regression was performed to assess for the risk of ureteral injury by surgical approach. Covariates included all significant variables from univariate analysis that were not collinear or lacking events. Another regression was performed for MIH to include uterine weight and specific technique (total, supracervical, or vaginal assisted) as covariates. Two-sided *P* values were reported for all statistical tests, and a *P* value <.05 was considered significant.

RESULTS

We identified 96,538 hysterectomies in the ACS-NSQIP database; 28,408 (29%) cases of AH, 51,293 (53%) cases of MIH, and 16,837 (17%) cases of VH. Comparison of patients who underwent AH and MIH revealed significant differences in baseline characteristics between these cohorts (Table 1). Patients who underwent MIH were younger, more likely Caucasian, and with lower body mass index (BMI) compared to those who underwent AH (all $P < .001$). Smokers were less likely to undergo MIH compared to AH (17.6% vs 18.2%, $P = .04$). Overall, there was a very low incidence of comorbidities in each cohort. Nevertheless, MIH had a lower likelihood of having almost any comorbidity compared to AH. Presence of senior residents was less in MIH compared to AH cases (37.1% vs 40.1%, $P < .001$).

MIH was associated with improved 30-day outcomes compared to AH (Table 2). MIH resulted in lower overall complications (6.6% vs 14.8%, $P < .001$) compared to AH. Considering the most frequent complications, patients with MIH had lower rate of wound complications (2.1% vs 4.7%, $P < .001$) and bleeding requiring transfusion (1.9% vs 7.4%, $P < .001$), but similar rates of UTI (2.3% vs 2.5%, $P = .10$) compared to those with AH. Patients who underwent MIH had shorter hospitalization (median 3 vs 1 days), as well as decreased reoperations, readmissions, and death compared to AH (all $P < .001$). However, there were strikingly higher rates of overall ureteral injury (0.48% vs 0.18%) and immediate ureteral repairs (0.42% vs 0.14%) in patients who underwent MIH compared to AH (both $P < .001$).

Overall iatrogenic ureteral injury and immediate ureteral repair rates for all types of hysterectomy are listed in Supplementary Table S3. There were 302 total ureteral injuries identified. The lowest rates of injury were in patients who underwent VH (0.04%), whereas the highest were in radical MIH (0.77%). For patients who underwent AH with immediate ureteral repairs, 23 (57.7%) underwent ureteral reimplantation, 11 (27.5%) underwent ureteroureterostomy, 5 (12.5%) underwent ureterorrhaphy