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# Open versus minimally invasive surgical approaches in pediatric urology: Trends in utilization and complications

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## Summary

### Objective
Minimally invasive surgery (MIS) techniques are anecdotally reported to be increasingly used, but little objective data supports this. Our objective was to assess trends in MIS utilization across various procedures in pediatric urology and to compare postoperative complication rates between MIS and open procedures.

### Methods
We analyzed the 1998–2012 Nationwide Inpatient Sample. We identified children (<18 years old) undergoing open and MIS inpatient procedures and any in-hospital post-operative complications that occurred during that postoperative hospitalization. We utilized propensity score matching and multivariable logistic regression to adjust for confounding factors.

### Results
We identified 163,838 weighted encounters in the "overall cohort," 70,273 of which were at centers performing more than five MIS procedures over the years studied. Use of MIS techniques increased significantly over time for several procedures, most prominently for nephrectomy (Fig.). The overall rate of complications was lower in patients undergoing MIS compared with open surgery (6% vs. 11%, $p < 0.001$). Specialized centers had a significantly lower overall rate of complications than unspecialized centers (9% vs. 12%, $p < 0.001$). Within specialized centers, MIS had lower complication rates than open procedures (7% vs. 9%, $p < 0.001$); this finding was consistent even after adjusting for other factors (OR 0.71, $p = 0.02$).

### Discussion
Limitations include that these data may not be generalizable to encounters not in the sample pool. As a large, retrospective, administrative database, NIS may be affected by miscoding bias – rendering our analysis sensitive to the accuracy of procedure coding in NIS. Although the accuracy level of NIS is high for an administrative database, it is possible at least some portion of our cohort may be incorrectly coded. Further, the NSQIP complications we identified may represent associated comorbidities and not true postoperative complications, as NIS does not provide temporal relationships between different diagnosis codes. Despite these limitations, we note that the NIS database is rigorously monitored and audited for coding accuracy and, therefore, represents a reasonably reliable panorama of the characteristics of an inpatient surgical cohort. However, it is important to note that the choice of operative modality is, undoubtedly, multifactorial and patient/setting-specific.

### Conclusions
There is increasing use of MIS for pediatric urology procedures, although utilization rates vary among procedures. MIS was associated with a lower postoperative complication rate than for open procedures. Higher-volume MIS centers have a lower complication rate than lower-volume centers.

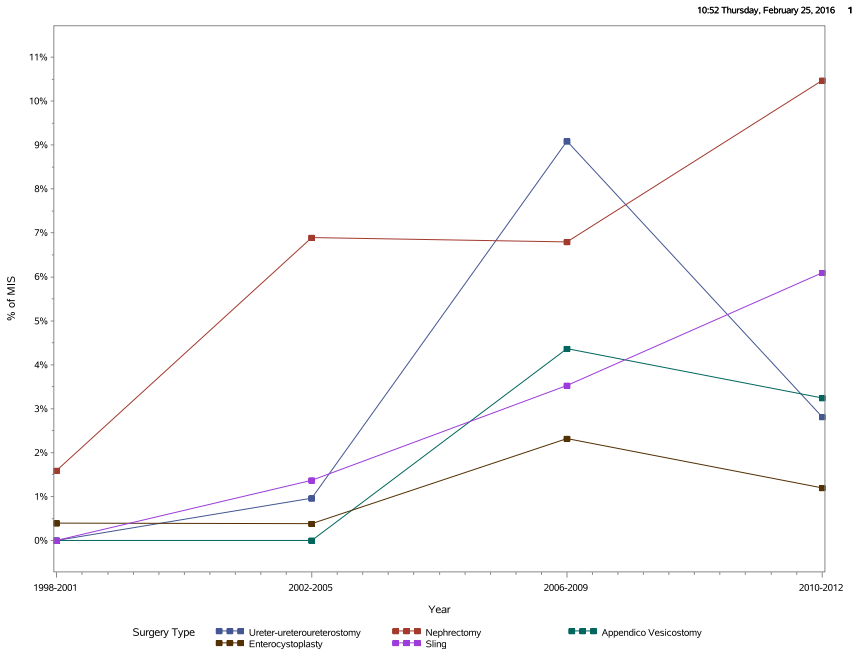


**Figure** Prevalence of MIS by procedure and year ($p < 0.03$ for all).

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## Introduction

Initially pioneered primarily as a diagnostic modality in the 1970s, the use of minimally invasive surgery (MIS) has become increasingly common in pediatric surgical practice following significant recent technological improvements [1–3]. Pediatric urologists have embraced MIS as technological improvements have come to market, altering the treatment landscape and permitting viable MIS approaches for many common urinary tract procedures in children [4]. This change has coincided with paradigm shifts among physicians and parents favoring less-invasive surgical techniques in children when possible, driven by reported improvements in cosmetic outcomes, more expedient postoperative discharge, and faster recovery times [5–8]. Extensive MIS training is now a component of most urological residency and fellowship programs in the USA, and urological procedures account for up to 15% of all laparoscopic operations performed in children domestically [9,10].

Use of MIS, however, is not without potential trade-offs. Both laparoscopy and robotic surgery require considerable resource expenditure in training and infrastructure [11,12]. Operative times for MIS are typically longer than comparable open approaches and are highly dependent on operator proficiency [13–15]. Yet, despite these substantial differences, studies directly comparing the outcomes from MIS and open approaches in pediatric urology are limited.

We sought to describe changes in the frequency of MIS use in pediatric urology in the USA over a 14-year period using a nationwide all-payer database and to characterize differences in the frequency of reported postoperative complications in MIS and open pediatric urological surgical approaches. We hypothesized that there would be an increase in both MIS utilization and MIS-related complications (because of individual provider learning curves) over time.

## Methods

### Data source

The Nationwide Inpatient Sample (NIS) is an all-payer database managed by the Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency for Healthcare Research and Quality. Data in the NIS are from a 20% stratified probability sample of US hospitals based on five hospital characteristics including ownership status, number of beds, teaching status, urban/rural location, and geographic region. NIS includes post-stratification discharge weights to estimate 35 million hospital admissions per year.

### Selection of patients and covariates

We selected all pediatric patients (<18 years old) between 1998 and 2012 undergoing procedures which could reasonably be performed open or with MIS and defined this as the "entire cohort." Procedures were defined by ICD-9-CM code (see Appendix 1 for codes and procedures); codes were previously validated at our institution to assure their accuracy [16,17]. We defined MIS procedures as those with a concurrent ICD-9-CM procedure code for laparoscopic/robotic assistance (54.51, 54.21, and/or 17.4x) [18–21]. We then refined our cohort to compare only hospitals that performed a minimum of five MIS cases per year to compare hospitals where enough MIS was performed presumably to minimize technical error and reduce complications. These encounters were defined as the "specialized cohort" in our analysis and included 59 of the 1308 hospitals in the original cohort. Predictor variables were selected *a priori*. Covariates included basic patient demographics: age, gender, race, insurance payer (public vs. private), median household income, Charlson comorbidity index, treatment year, treatment modality, and hospital-level factors (teaching status and geographic region).

### Outcome selection

The primary outcome was postoperative complications; these were identified by ICD-9-CM codes (Appendix 2) which most closely corresponded to the complications described by the National Surgical Quality Improvement Program (NSQIP). Rare complications (≤15), while included in the analysis, were excluded from data tables per AHRQ requirements. For secondary outcomes, we analyzed the prevalence of MIS techniques for individual procedures over time and modeled the predictors of receiving MIS, adjusting for covariates.

### Statistical analysis

We used descriptive statistics to describe the demographics of each cohort. Wald chi-square test was used to compare discrete variables and ANOVA was used for continuous variables to take into account the stratum, clusters, and weights present in the data set.

Using the "entire cohort," we determined the overall frequency of complications and percentage of individual procedures performed using MIS. Encounters were subcategorized into four time periods (years 1998–2001, 2002–2005, 2006–2009, 2010–2011) to account for small numbers of observations in individual years. We then created heat maps (Fig. 1) to assess national trends in utilization (2012 was excluded from these maps as NIS did not report each hospital's state for that year). States were excluded from the heat maps if they did not participate at any time in NIS.

To ensure a fair comparison within the "specialized cohort," we used propensity scores (PS) to match patients on surgery type. We adjusted for age, gender, race, Charlson Comorbidity Score, hospital bed size, hospital type, region, and year. Multiple imputation was used for missing data. We created 15 imputed data sets and exported them to R to perform propensity matching to create 15 matched data sets using the Matchit macro. As open surgery was expected to be significantly more prevalent than MIS, we used a control:case ratio of 3:1 using the "greedy" nearest neighbor method. We used PS matching jitter and love plots to assess how well the matching was performed.