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Open versus minimally invasive ureteroneocystostomy: A population-level analysis

Hsin-Hsiao S. Wang [a,1], Rohit Tejwani [a,1], Glenn M. Cannon Jr [b], Patricio C. Gargollo [c], John S. Wiener [a], Jonathan C. Routh [a]

[a]Division of Urologic Surgery, Duke University Medical Center, Durham, NC, USA

[b]Division of Pediatric Urology, Children's Hospital of Pittsburgh, Pittsburgh, PA, USA

[c]Department of Urology, Mayo Clinic, Rochester, MN, USA

Correspondence to: Jonathan C. Routh, Division of Urologic Surgery, Duke University Medical Center, DUMC 3831, Durham, NC 27710, USA, Tel.: +1 (919) 684 6994; fax: +1 (919) 681 5507

jonathan.routh@duke.edu (J.C. Routh)

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Summary

Introduction
Open ureteroneocystostomy (UNC) is the gold standard for surgical correction of vesicoureteral reflux (VUR). Beyond single-center reports, there are few published data on outcomes of minimally-invasive (MIS) UNC. Our objective was to compare postoperative outcomes of open and MIS UNC using national, population-level data.

Method
We reviewed the 1998–2012 Nationwide Inpatient Sample to identify pediatric (≤18 years) VUR patients who underwent either open or MIS UNC. Demographics, National Surgical Quality Improvement Program (NSQIP) complications, length of stay (LOS), and cost data were extracted. Statistical analysis was performed using weighted, hierarchical multivariate logistic regression (complications) and negative binomial regression (LOS, cost).

Results
We identified 780 MIS and 75,976 open UNC admissions. Compared with patients undergoing open UNC, patients who underwent MIS UNC were likely to be older (6.2 versus 4.8 years, $p < 0.001$), publically insured (43 versus 26%, $p < 0.001$), and treated in recent years (90 versus 46% after 2005, $p < 0.001$). MIS admissions were associated with a significantly shorter length of stay (1.0 versus 1.8 days, $p < 0.001$) and higher cost ($9230 versus $6,304, $p = 0.002$). After adjusting for patient-level confounders (age, gender, insurance, treatment year, and comorbidity), and hospital-level factors (region, bedsize, and teaching status), MIS UNC was associated with a significantly higher rate of postoperative urinary complications such as UTIs, urinary retention, and renal injury (OR 3.1, $p = 0.02$), shorter LOS (RR 0.8, $p = 0.02$), and higher cost (RR 1.4, $p = 0.008$).

Discussion
Strengths of this study are its large cohort size, long time horizon, national estimation, and cost data. Most prior studies are case-series limited to the size of the institutional cohort. Our analysis of 76,756 operative encounters revealed that open UNC continues to be performed at far greater frequency than MIS UNC, outpacing the latter modality by nearly 100:1. Children treated with MIS UNC had three times greater odds of developing postoperative urinary complications, and MIS UNC patients incurred average costs per admission that were nearly 1.5 times higher than those of children who underwent open UNC. These children were also likely to be older, publically insured, and treated in more recent years. On the other hand, patients treated with MIS UNC required substantially shorter postoperative hospitalization, with an average LOS roughly half that of open UNC cases. Limitations include the retrospective nature of the administrative database, lack of detailed patient-level data, and no available long-term postoperative outcomes. Compared with open surgery, MIS UNC was associated with shorter LOS but higher costs and possibly higher urinary complication rates.

Table Bivariate/multivariate analysis of postoperative complications for MIS UNC.

NSQIP complications[a]	Unadjusted OR (95% CI)	Adjusted OR[b] (95% CI)	*p* value[b]
UTI	1.00 (0.37–2.72)	0.99 (0.40–2.44)	0.98
Urinary complications	2.63 (1.00–6.91)	3.13 (1.17–8.40)	0.02
All complications	1.15 (0.48–2.78)	1.27 (0.57–2.85)	0.56

[a] Using open UNC as reference.
[b] After adjusting for age, gender, insurance, year, comorbidity, teaching status, hospital region, and hospital size.

[1] Dr. Wang and Mr. Tejwani contributed equally to this manuscript.

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Introduction

Vesicoureteral reflux (VUR) is a commonly encountered problem in pediatric urologic practice, affecting approximately 1% of all children and up to 70% of those presenting with a febrile UTI [1]. Given this common incidence, the economic impact from VUR has been found to be significant, with care-related charges exceeding $100 million annually in the USA [2]. Optimal management strategies for this condition are controversial and continue to be debated as our understanding of its pathophysiology, clinical course, and long-term sequelae evolve [3,4]. Although the vast majority of cases of VUR resolve spontaneously and do not require surgical management, surgical interventions may be warranted in patients with persistent VUR and/or recurrent febrile UTI to reduce risk of renal scarring and loss of kidney function [3,5].

Open ureteroneocystostomy (UNC) has served as the cornerstone of surgical management of VUR for over 50 years and continues to play a prominent role in modern management algorithms [6,7]. Endoscopic correction of VUR with injection of bulking agents has been available in the USA for over 10 years, but its success rate has never equaled that of UNC, particularly in higher grades of VUR [8]. Significant advances in laparoscopic and robotic technology have coupled with a paradigm shift among providers and families favoring preferential use of less-invasive surgical approaches in children and resulted in a rise in the use of minimally invasive surgery (MIS) in pediatric urology, including MIS UNC [9]. Yet, despite substantial differences in invasiveness, cost, and intra/postoperative characteristics, there are few multi-center studies directly comparing operative outcomes between open and MIS UNC approaches [9]. Given current efforts to improve care quality and optimize cost management, broader-encompassing comparisons are particularly salient.

We sought to characterize postoperative outcomes, including length of stay (LOS), cost, and National Surgical Quality Improvement Program (NSQIP) postoperative complication rates, for pediatric (aged $\leq$18 years) patients who underwent surgical intervention for VUR with either open or MIS UNC between 1998 and 2012 using the Nationwide Inpatient Sample (NIS), a nationally representative inpatient administrative database. We hypothesized that complication rates and cost would be higher for MIS surgeries, whereas LOS would be longer for open surgeries.

Materials and methods

Data source

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 (AHRQ). NIS is derived from a 20% stratified probability sample of US hospitals, including both children's and adult 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 that may be used to calculate national estimates [10].

Selection of patients and covariates

We identified all inpatient hospital encounters occurring between 1998 and 2012 for pediatric patients (aged $\leq$18 years) with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code for VUR (593.7) who underwent UNC (56.74). MIS UNC was differentiated from open UNC using additional procedure codes 17.4, 54.21, 54.51, indicative of UNC involving robotic surgery (17.4) or laparoscopy (54.21, 54.51).

Predictor variables were a priori selected based on biologic plausibility and/or demonstrated associations in the literature. Covariates included basic patient demographics: age, gender, race, insurance payer (public versus private), median household income quartiles by zip code, Charlson comorbidity index, treatment year, and treatment modality (open versus MIS). We also extracted hospital-level factors: hospital characteristics such as hospital teaching status (metropolitan non-teaching, metropolitan teaching, and non-metropolitan) and geographic region (Northeast, South, Midwest, and West), and center size.

Outcome selection

The primary outcome was in-hospital postoperative complications; these were identified by the ICD-9-CM code (Appendix 1) as defined by NSQIP [11,12]. We included UTI, postoperative urinary complications including urinary retention, acute renal insufficiency, urinary tract infections (ICD-9-CM diagnosis code 997.5), pneumonia, and bleeding as the main outcomes. We also examined length of stay (LOS), and total hospital costs per admission. Rare complications ($n \leq 15$) were removed from the analysis as per AHRQ regulations prohibiting publication of rare events. Among the NSQIP-identified complications, there were too few events for postoperative surgical site infection (superficial and deep), peritoneal abscess, acute renal failure, respiratory complications, ARDS, pulmonary embolism, postoperative respiratory insufficiency, prolonged mechanical ventilation (>96 h), sepsis, cerebrovascular accident, postoperative cardiac complications, acute myocardial infarction, cardiac arrest or other cardiac complications, deep vein thrombus, or in-hospital death to perform a thorough analysis; these complications were, therefore, excluded.

Statistical analysis

Bivariate analyses were performed to compare patient demographics and hospital-level characteristics of patients who received open and MIS UNC. We used the Rao—Scott chi square test, *t* test, or Wilcoxon rank-sum test as appropriate based on data characteristics and distribution. All analyses were weighted using NIS-specific estimated weights and covariance matrices accounting for the complex survey design. NIS cost-to-charge files were used to convert hospital charges to cost [2]. Multivariate logistic regression (NSQIP in-hospital postoperative complications, in-hospital deaths) and negative binomial regression (LOS, cost) were fitted to examine factors, specifically surgical modality (open versus MIS), that predicted the outcomes. Generalized estimating equations were used to account for