Minimally Invasive vs Open Pyeloplasty in Children: The Differential Effect of Procedure Volume on Operative Outcomes

Shyam Sukumar, Orchidee Djahangirian, Akshay Sood, Jesse D. Sammon, Briony Varda, Kirsten Janosek-Albright, Abd-El-Rahman Abd-El-Barr, Maxine Sun, and Quoc-Dien Trinh

OBJECTIVE To assess the differential effect of volume-outcome dynamics on the outcomes of open pyeloplasty (OP) and minimally invasive pyeloplasty (MIP) in the management of pediatric ureteropelvic junction obstruction in the setting of increasing utilization of MIP.

METHODS Within the Nationwide Inpatient Sample, a weighted estimate of 6006 pediatric patients (≤18 years; 2008-2010) with ureteropelvic junction obstruction underwent either OP or MIP. National trends in utilization and comparative effectiveness outcomes were examined in terms of intraoperative and postoperative complications, prolonged length of stay, and excessive hospital charges. Hospitals were stratified into volume quartiles. Specifically, the volume-outcome dynamics of the highest and lowest volume quartiles of both the approaches were examined with binary logistic regression models.

RESULTS MIP accounted for 17.2% of cases during the study years. In individual multivariate models, high-volume OP patients had a significantly lower risk of developing postoperative complications, genitourinary complications, and excessive hospital charges compared with high-volume MIP, low-volume OP, and low-volume MIP patients. Regardless of hospital volume, MIP patients experienced shorter hospital stays.

CONCLUSION Although there has been a substantial increase in the utilization of MIP, high-volume hospitals performing OP have the best perioperative outcomes in terms of postoperative complications, genitourinary complications, and overall hospital charges. However, high-volume hospitals performing MIP have better outcomes compared with low-volume hospitals performing OP. Shorter hospital stay is the one mitigating factor of MIP. UROLOGY ■: ■—■, 2014. © 2014 Elsevier Inc.

Dismembered open pyeloplasty (OP) has been the traditional gold standard for the correction of ureteropelvic junction obstruction (UPJO) in children since its initial description by Anderson and Hynes[1] in 1949. However, over the last 2 decades, a number of minimally invasive approaches have been increasingly used for correction of UPJO in children.[2] Peters et al[3] reported the first case of a child undergoing UPJO correction via laparoscopic pyeloplasty in 1995, followed by reports of robot-assisted laparoscopic pyeloplasty by Guillonneau et al[4] and Graham et al[5] in 2001. Since then, multiple single-center studies looking at perioperative outcomes of these approaches have established the safety and comparative efficacy of minimally invasive pyeloplasty (MIP).[6-11]

Although minimally invasive platforms, specifically robotic assistance, have been shown to be superior to conventional approaches in terms of perioperative morbidity in the treatment of other diseases such as prostate cancer,[12,13] these outcomes were found to be heavily contingent on the specifics of the volume-outcome dynamics of the procedure.[14] As such, results from single-center studies looking at MIP for UPJO correction should be carefully evaluated in this context before any conclusion is drawn.

Hence, in the present study, we sought to evaluate the differential effect of hospital volume on perioperative outcomes after OP and MIP in a large, contemporary, nationally representative pediatric population.

Shyam Sukumar and Orchidee Djahangirian contributed equally.

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From the Center for Outcomes Research and Analytics, Henry Ford Health System, Detroit, MI; the Vattikuti Urology Institute, Henry Ford Health System, Detroit, MI; the Cancer Prognostics and Health Outcomes Unit, University of Montreal, Montreal, Quebec, Canada; the Division of Urologic Surgery, Brigham and Women's Hospital, Harvard Medical School, Boston, MA; and the Center for Surgery and Public Health, Brigham and Women's Hospital, Harvard Medical School, Boston, MA.

Reprint requests: Quoc-Dien Trinh, M.D., Division of Urologic Surgery, Brigham and Women's Hospital, Harvard Medical School, 45 Francis St, ASB II-3, Boston, MA 02115. E-mail: trinh.qd@gmail.com

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MATERIALS AND METHODS

Data Source

The Nationwide Inpatient Sample, initiated as a part of the Healthcare Cost and Utilization Project, is the largest, publicly accessible, all-payer, inpatient data set in the United States. It contains information from around 8 million inpatient stays annually and represents a 20% stratified sample of all hospital admissions in the United States.[15]

Study Cohort

The study population consisted of patients ≤18 years of age who underwent treatment for UPJO (International Classification of Disease, Ninth Revision, Clinical Modification [ICD-9-CM] code 55.87) between the last quarter of 2008 (ie, after introduction of the procedure code for robotic assistance) and the end of 2010. MIP patients were identified based on the codes for robotic assistance (ICD-9-CM code 17.4x) or laparoscopic exploration (ICD-9-CM code 54.21). Patients with UPJO who underwent endopyelotomy were excluded based on codes for ureteroscopy and pyelotomy. All other patients were categorized as having had OP.

Covariates and Outcomes

Patients were substratified into age groups: infants (<1 year), preschool (1-5 years), grade school (6-9 years), preadolescent (10-13 years), and adolescent (14-18 years).[16] We ascertained the Charlson comorbidity index based on the previously reported work of Charlson et al,[17] with modifications according to Deyo et al.[18] Median household income of the patient's zip code of residence was used as a surrogate for socioeconomic status, and patients were classified into quartiles: <$25,000, $25,000-$34,999, $35,000-$44,999, and ≥$45,000. Hospital-level factors included annual hospital volume, academic status, hospital region, and hospital location. Hospital academic status, hospital location, and hospital region were ascertained as reported previously.[19] The annual hospital volume was divided into quartiles for each procedure (OP and MIP) with a specific focus on the highest (high volume [HV]) and lowest (low volume [LV]) quartiles for each procedure type. Hospitals performing ≥35 OP and ≥41 MIP were considered HVOP and HVMIP, respectively. Similarly, hospitals performing ≤16 OP and ≤13 MIP were considered LVOP and LVMIP, respectively.

Intraoperative and postoperative complications and mortality were identified using modifications of the previously described methodology.[20,21] Specifically, the genitourinary complications included postoperative occurrences of anastomotic complications, oliguria and/or anuria, renal insufficiency, or acute tubular necrosis. The gastrointestinal complication included postoperative intestinal obstruction. The length of stay was examined by subtracting the date of admission from the date of hospital discharge. Prolonged length of stay (PLOS) was defined as length of stay ≥75th percentile. Excessive hospital charges (EHCs) were defined as charges ≥75th percentile after adjusting for inflation. Adjustment for inflation (to 2012 dollars) was done using the consumer price index inflation calculator from the Bureau of Labor Statistics.[22] As stent placement may confound cost differences between the 2 techniques, additional procedure codes were used to identify concurrent stent placements, and these cost charges were subsequently removed from the total cost.

Statistical Analysis

The chi-square test was used for categorical comparisons. Binary logistic regression models were used to examine for predictors of intraoperative and postoperative complications, EHC, and PLOS. Separate regression models were used to assess for predictors of receipt of pyeloplasty at HV hospitals (regardless of the procedure type) to assess for disparities in access to care. Statistical analyses were performed using the R statistical package (version 2.15.1; the R Foundation for Statistical Computing) and SPSS (version 20; IBM). All tests were 2-sided, and statistical significance was set at $P < .05$.

RESULTS

Between October 2008 and December 31, 2010, an estimated 6006 pediatric patients underwent pyeloplasty for UPJO, including MIP in 1029 (17.2%) and OP in 4977 (82.8%). Table 1 lists the characteristics of the patients who underwent pyeloplasty at centers comprising the highest and lowest volume quartiles of both these procedures (HVOP, HVMIP, LVOP, and LVMIP). The groups differed significantly in terms of age, gender, race, comorbidity, insurance status, and median household income. HV centers were teaching hospitals located in urban areas.

Table 2 summarizes the perioperative outcomes of the patient population. There was no in-hospital mortality. Overall postoperative complication rates were 5.7%, 11.7%, 10.4%, and 16.4% in HVOP, HVMIP, LVOP, and LVMIP, respectively ($P < .001$). Moreover, 22.7% and 33.4% of patients who received treatment at HVOP and LVOP, respectively, had PLOS as opposed to 9.9% and 16.8% patients treated at HVMIP and LVMIP, respectively ($P < .001$). EHCs were noted in 10.6%, 22.1%, 22.3%, and 54.3% of patients being treated at HVOP, HVMIP, LVOP, and LVMIP, respectively ($P < .001$). On multivariate logistic regression analysis (Table 3), HVOP was associated with significantly fewer genitourinary complications and less EHC in comparison with HVMIP, LVOP, and LVMIP. Overall postoperative complications were similar in HVOP and HVMIP (odds ratio [OR], 1.42; $P = .184$) but higher in LVOP and LVMIP (OR, 2.1; $P < .001$; OR, 3.0; $P < .001$, respectively). MIP was associated with lower PLOS irrespective of the volume of the center. Furthermore, HVMIP was associated with significantly lower PLOS and EHC in comparison with LVOP (OR, 0.23; $P < .001$; OR, 0.62; $P = .025$, respectively), but both were similar with regards to other perioperative parameters assessed (Table 4).

Supplementary Table 1 summarizes the predictors of access to HV centers (both HVOP and HVMIP) in comparison with LV centers (both LVOP and LVMIP). Adolescents and people insured with Medicaid were more likely to get treatment at LV centers (OR, 0.19; $P < .001$; OR, 0.64; $P = .001$, respectively), whereas people living in the high-income areas were more likely to get treatment at HV centers (OR, 2.23; $P < .001$).

COMMENT

There has been a substantial increase in the use of MIP in the United States in the last decade, driven primarily by robotic pyeloplasty.[2] Contemporary reports indicate that