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Are there disparities in access to robot-assisted laparoscopic surgery among pediatric urology patients? US institutional experience

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Objective: Literature suggests access to robotic surgery varies by race and payer status. We seek to investigate whether disparities exist in robot-assisted laparoscopic surgery among the pediatric urology population at our tertiary academic medical center and, if so, to find plausible reasons why.

Methods: Retrospective analysis identified patients who underwent open or robot-assisted laparoscopic surgery by a single surgeon at a tertiary care center between 2008 and 2019. Univariate and multivariate analyses determined the relationship of patient demographic and socioeconomic factors to procedure approach.

Results: Among 356 patients, race, age, American Society of Anesthesiologists status, and year of surgery were significant by univariate analysis. Insurance status was not significant ($P = 0.066$). Multivariate analysis indicated that age, American Society of Anesthesiologists status, and year of surgery were statistically significant ($P < 0.001$, $P = 0.005$, $P < 0.001$). By multivariate logistic regression, Black and Hispanic patient race were not significant with an odds ratio of 0.60 (0.35–1.02) ($P = 0.061$). In 60.2% of open cases, open approach selection was attributable to complex pathology, limitations of robotic approach, and surgeon's robot-assisted laparoscopic learning curve.

Conclusions: Optimal procedure approach was determined by case complexity and surgeon's robot-assisted laparoscopic learning curve and was independent of patient race and payer status. This study did not find racial or socioeconomic disparities in robotic surgery within pediatric urology at our tertiary medical center, inconsistent with previous literature.

Key words: healthcare disparity, insurance coverage, pediatric urology, robot-assisted laparoscopy, socioeconomic factors.

Introduction

While utilization of the minimally invasive RAL approach has increased over time, significant disparities in access persist by patient race, ethnicity, and payer status. While debate continues regarding the technical and clinical benefits[1] of robotic surgery, this manuscript primarily explores availability of RAL by patient socioeconomic status. RAL candidacy can be determined by the patient's current health status, severity of disease process, comorbidities, and past surgical history. Despite said objective criteria, research findings indicate that a subgroup of historically disadvantaged patients do not have equal access to the RAL approach.[2]

With respect to urological care, it is well-documented that social and racial factors have contributed to differences in access to robotic technology among adult urologic patients.[3] For instance, findings indicate that Black, Hispanic, and Medicaid patients are less likely to undergo the RAL surgery.[4] Specifically, Black patients were 22% less likely to undergo MIRP when compared to non-Hispanic White patients between the years of 2001 and 2005. Furthermore, Medicaid patients were 46% less likely to undergo MIRP than privately insured patients.[5] However, racial disparities in access to RAL procedures have not been well studied in more recent years, since the widespread adoption of the technology. Furthermore, the majority of the literature describes disparities among adult urology patients with a paucity of literature exploring disparities among pediatric patients, particularly within urology.

The purpose of this study is to determine whether there is an association between the robotic approach and patient race, ethnicity, and payer status among pediatric urology patients

who underwent pyeloplasty, ureteral reimplantation, and urinary continence procedures at our tertiary care center. This study seeks to investigate the nature of treatment received by patients who are able to present for care and does not aim to identify or rectify barriers to presenting for treatment. We hypothesized that there would be fewer Black, Hispanic, and Medicaid patients treated by robotic approach compared to non-Hispanic White and privately insured patients based on previous literature indicating racial and ethnic disparities in access to robotic procedures over the last two decades.

Methods

A retrospective review was performed to identify pediatric urology patients of a single surgeon at our tertiary care center between December 2007 and December 2019. Initially, 2497 patients were identified. Inclusion criteria were limited to patients who underwent pyeloplasty, ureteral reimplantation, or urinary continence procedures (appendicovesicostomy, augmentation cystoplasty, and bladder neck continence procedures). These procedure types were selected as they are routinely performed by either the robotic or open approach. In patients who received multiple surgical interventions, only the primary procedure was considered as subsequent procedures were due to disease pathology or surgical complications and inclusion of said procedures would inflate the data. Patients greater than 18 years of age at the time of procedure were excluded. Patients without self-reported race and ethnicity documented in their medical record were excluded. In total, 356 cases were included for analysis.

Extracted demographic data included patients' self-reported race at time of patient chart creation with options including White/Caucasian, Black/African American, American Indian, Asian (Asian sub-categories also listed), or Other. For the purposes this study, Asian, American Indian, and Other race were combined into an overall "Other" racial category. Additionally, patients could self-identify ethnicity as Hispanic/Latino or non-Hispanic/Latino. Patients who identified ethnically as Hispanic and patients who identified as Black were combined into one group. Payer status (public, private, other) was retrospectively collected for research purposes. Secondary variables included age and BMI. Additionally, to capture evolving catchment area demographics and serve as a surrogate for surgeon's RAL learning curve, the year of surgery completion was collected. Year of surgery was broken down into three categories to equally distribute case load across the years studied: "early" for surgeries that occurred from 2007 to 2010, "middle" for surgeries that occurred from 2011 to 2014, and "late" for surgeries that occurred from 2015 to 2019. ASA physical status classification was collected as an objective measure of preoperative health and fitness to determine operative risk. Lastly, documentation of patient encounters, in which shared decision-making took place, was systematically reviewed to collect and categorize reasons for open approach selection. This study received institutional review board approval (IRB20-0079).

Univariate analysis identified factors with statistically significant association with robotic procedure approach using logistic regressions and chi-square tests where appropriate.

Variables with *P*-value less than or equivalent to 0.05 were included in a multivariable logistic regression model for robotic approach using a generalized estimating equation. Variables with $P < 0.05$ in the multivariate model were considered significant, and the 95% CIs and *P* values were reported. Statistical analysis was performed with Stata/IC 16.1 (College Station, TX, USA).

Results

Between 2007 and 2019, 356 procedures performed by a single surgeon at our tertiary care children's hospital met inclusion criteria and were analyzed. Of the total procedures studied, 258 were RAL cases and 98 were open cases. Overall, there were 165 pyeloplasty (RAL = 126, O = 39), 123 ureteral reimplantation (RAL = 90, O = 33), and 68 urinary continence (RAL = 42, O = 26) procedures performed (Table 1). Among 356 cases, 162 (45%) occurred in non-Hispanic White patients, 152 (43%) in Black and Hispanic, and 42 (12%) in Other (Table 1).

Univariate analysis determined that mean age, ASA status, year of surgery, and patient race/ethnicity had statistically significant relationships with procedure approach ($P < 0.001$, $P = 0.013$, $P < 0.001$, $P = 0.019$, respectively). Insurance payer status and patient BMI were not statistically significant with respect to surgical approach ($P = 0.066$, $P = 0.168$) (Table 1). Figure 1 describes the patient cohort by race/ethnicity, surgery type, and surgical approach.

By multivariate analysis with age, ASA status, and year of surgery controlled, no differences were found in the likelihood of Black and Hispanic patients undergoing surgery by RAL approach compared to their White counterparts with an OR of 0.60 (95% CI 0.35–1.02, $P = 0.061$). In contrast, age (OR 1.18; $P < 0.001$), year of surgery [(middle: OR 2.98; $P < 0.001$), (late: OR 5.70; $P < 0.001$)], and ASA status ≥ 3 (OR 0.34; $P = 0.005$) continued to be significantly associated with the robotic procedure approach (Table 2).

Total cases analyzed by year across the study period from 2008 to 2019 demonstrated that for years 2010, 2012, and 2014, White race compromised the largest proportion of all patient races and ethnicities (Fig. 2). In the years 2008 and 2019, Black and Hispanic patients made up a majority of all patient races/ethnicities (Fig. 2). Across the duration of the study period (2008–2019), the proportion of all surgery conducted by RAL approach steadily increased from 47% in 2008, when RAL surgery was first introduced at our institution, to 91% in 2019 (Fig. 2).

To investigate factors contributing to selection of surgical approach, documentation of shared decision-making during patient encounters was evaluated and reasons for open surgical approach were recorded and categorized yielding three main categories—anatomical complexity, patient factors (age, comorbidities), and surgeon's RAL learning curve (Table 3). For context, at our medical center, the RAL approach was first utilized for adult and pediatric bladder augmentation and urinary continence procedures in 2007 and progressed to include pediatric pyeloplasty procedures by 2010. By 2011, RAL approach consistently compromised the majority of conducted surgeries (Fig. 2). Therefore, before 2011, any open

procedure that did not have explicit documentation of reason for open approach selection was classified as pertaining to the surgeon's RAL learning curve. The primary indications for open approach included anatomical complexity (58%), patient factors (5%), and surgeon's RAL learning curve (37%) (Table 3).

Discussion

Prompted by literature describing disparities among adult urologic patients based on race and insurance status, this study investigated the possible existence of socioeconomic disparities in access to RAL surgery among pediatric urologic patients at our tertiary care center. By retrospective review and subsequent univariate analysis, insurance payer status (public, private, other) was not significantly associated with surgical approach. Multiple factors may contribute to our finding that payer status is not significantly associated with approach type. The first of which is that our institution resides in a state that expanded Medicaid, public insurance, in 2014.[7] According to the United States Census Bureau, in 2019, 21.9% to 24% of our state's population was enrolled in Medicaid, compared to the national rate of 19.8%.[7,8] Second, Medicaid enrollment criteria for children varies from that of adults and may account for a higher proportion of pediatric urologic patients insured by Medicaid than adult urologic

patients. Lastly, insurance status was collected retrospectively for study purposes and not reviewed at the time of surgery and therefore, it is unlikely that insurance status influenced approach selection.

Univariate analysis indicated that age ($P < 0.001$), ASA status ($P = 0.013$), and year of surgery ($P < 0.001$) should be controlled for in the multivariate analysis to determine the significance of race and ethnicity in surgical approach. Age and ASA status are variables that help determine patient physical compatibility with RAL surgery. Even with technological experience and training, RAL surgery may not be feasible for very young patients with smaller intraperitoneal cavities or patients with ASA values of three or more, which is often associated with medical comorbidities, complex anatomy, and prior abdominal reconstructive surgeries. Multiple studies, however, indicate that continuing expansion in RAL surgery is beginning to show improved outcomes in patients less than 1 year of age.[9–11]

With age, ASA status, and year of surgery controlled for, Black and Hispanic patients had no statistically significant difference in odds of undergoing surgery by RAL approach compared to their White counterparts with an OR of 0.60 (95% CI 0.35–1.02, $P = 0.061$). To better understand the relationship between race/ethnicity and surgical approach, the time fixed effect allows us to better understand the dynamic nature of both utilization of the RAL surgical technique and the institution's catchment area demographics. At the start of the study period, around 2008, non-Hispanic White patients made up a small percentage of procedure and the majority of procedures occurred by open approach. We propose that our institution's catchment demographics evolved either by increasing radius of catchment area or by the forces of gentrification. For instance, based on United States Census Bureau data, between 2012 and 2017, the five neighborhoods most proximal to our hospital collectively lost approximately 5272 Black residents, a trend consistent with the loss of Black residents across the city since 1980.[12,13] Additionally, at our institution, the RAL technique was first implemented in 2008 but it was not until 2011 that the RAL surgical technique was consistently utilized in the majority of cases. Beginning in 2010 through 2018, the proportion of White patients was the largest and at times, doubled that of Black and Hispanic patients (Fig. 2). For example, in the year 2012, the proportion of surgeries completed by RAL surgical approach was 73%, the highest it had been since its implementation in 2008, and the racial distribution was 29% Black and Hispanic and 59% White (Fig. 2). In subsequent years, the proportion of surgeries conducted by RAL surgical approach continued to grow while the relative racial distributions remained fairly static. Furthermore, the relatively early adoption of new robotic technology in 2008 may have played a role in the expansion of the institution's catchment area by appealing to well-resourced patients desiring the benefits offered by RAL approach *vs* open approach. While correlation between implementation of robotic technology and catchment demographics would be of interest, it is beyond the scope of this study and to imply causation would be beyond the scope of these data.

In conjunction with investigating disparities in access to RAL procedures, we also aimed to better understand factors influencing selection of surgical approach due to the lack of a

Table 1 Patient characteristics of open and RAL surgery

Category	Open n (%)	RAL n (%)	P-value*
Total patients	98 (27.5)	258 (72.5)	
Patient demographics			
Mean age at surgery, years (SD)	3.46 + 4.55	6.36 + 5.01	<0.001*
Year of surgery			<0.001*
Early (2007–2010)	55 (42)	75 (58)	
Middle (2011–2014)	37 (21)	143 (79)	
Late (2015–2019)	6 (13)	40 (87)	
Race/ethnicity			0.019*
Non-Hispanic White	34 (21.0)	128 (79.0)	
Black and Hispanic	55 (36.2)	97 (63.8)	
Other	9 (21.4)	33 (78.6)	
Sex			0.189
Male	60 (30.0)	138 (70.0)	
Female	38 (24.0)	120 (76.0)	
Insurance status			0.066
Private	43 (22.8)	146 (77.2)	
Public	54 (33.5)	107 (66.5)	
Other	1 (16.7)	5 (83.3)	
Mean BMI (SD)	17.77 + 3.82	18.48 + 4.52	0.168
Clinical presentation			
Disease severity (ASA status)			0.013*
Mild/Moderate (ASA 1–2)	77 (25.2)	229 (74.8)	
Severe (ASA >3)	21 (42.0)	29 (58.0)	
Procedure			0.074
Pyeloplasty	39 (23.6)	126 (76.4)	
Ureteral reimplantation	33 (26.8)	90 (73.1)	
Urinary continence procedure	26 (38.2)	42 (61.8)	

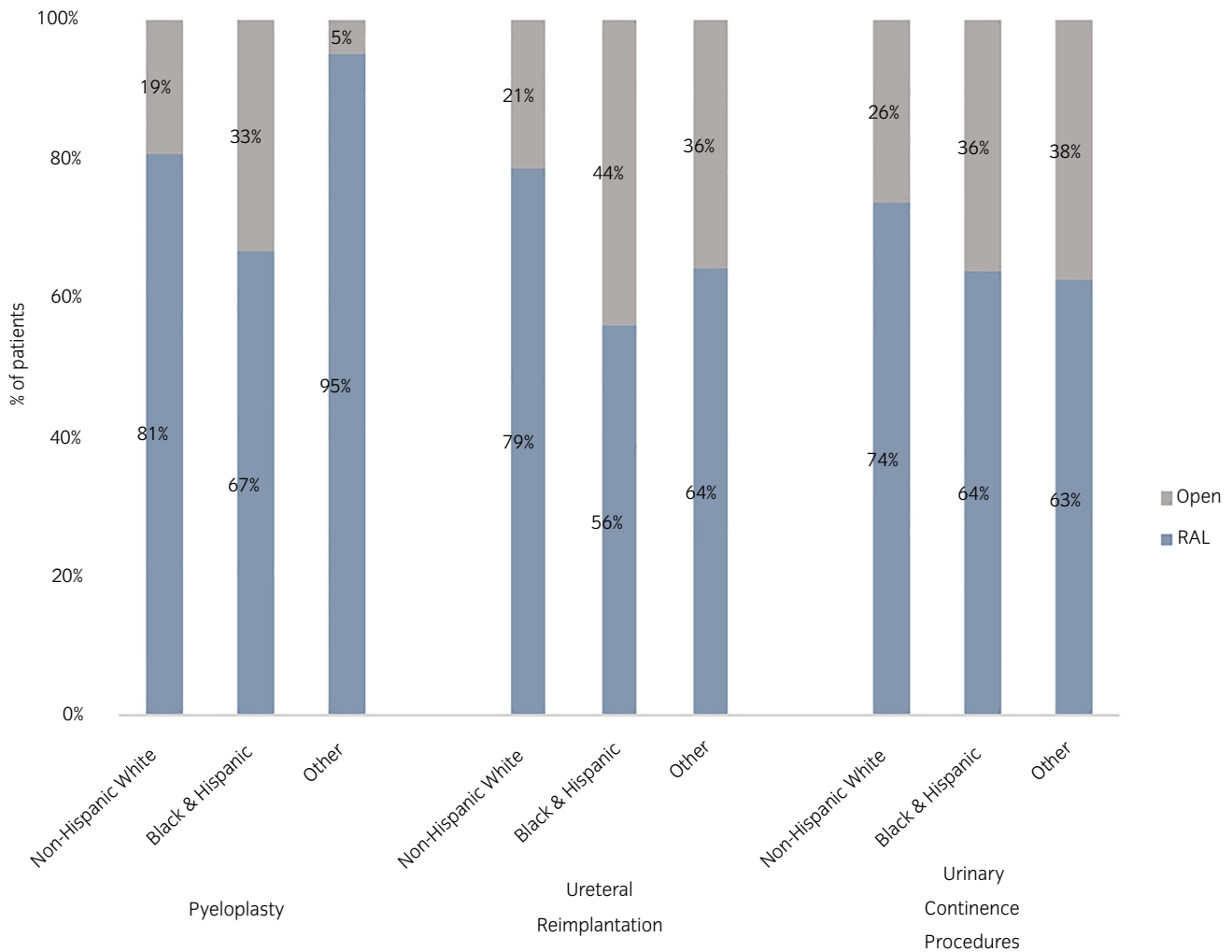*Statistical significance at $P < 0.05$.

Fig. 1 Patient race and ethnicity by procedure type and approach.

standardized clinical tool used in this decision-making. Among all open cases, 58% cited anatomical complexity as the primary reason for determination of open approach. Age and ASA status are objective variables used to describe the complexity of the intraperitoneal space and were statistically

Table 2 Multivariable logistic regression analysis of RAL approach

Variable	OR	95% CI	*P*-value
Race			
Non-Hispanic White	Reference		
Black & Hispanic	0.60	0.35–1.02	0.061
Other	1.23	0.50–3.03	0.645
Age (continuous)	1.18	1.09–1.29	<0.001*
Year of surgery			
Early (2007–2010)	Reference		
Middle (2011–2014)	2.98	1.71–5.20	<0.001*
Late (2015–2019)	5.70	2.21–14.66	<0.001*
ASA status			
1–2	Reference		
≥3	0.34	0.16–0.72	0.005*

*Statistical significance at *P* < 0.05.

significant with respect to surgical approach, as previously discussed. The second most common primary reason for selection of open approach was "RAL learning curve," which was cited in 37% of all open cases. Further investigation revealed that 56% of all open surgeries occurred during the first 4 years of the 12-year study period, consistent with initiation of RAL learning curve. Prior research has evidenced that differences in outcomes of RAL procedures by new and experienced surgeons were primarily attributable to the context in which care was delivered and complexity of the patient and not attributable to surgeon learning curve.[14] However, these data were not available during the years immediately following RAL implementation in 2008 and therefore, management by open approach remained the predominant approach until the RAL learning curve was sufficiently surmounted around 2011 at our institution. Determination of RAL proficiency is currently a topic of interest but such exploration is beyond the scope of this study and is investigated in a separate manuscript.

While our study demonstrates that there are no racial disparities in access to RAL surgery at our tertiary care center, it is vital that this study is interpreted for what it is—one
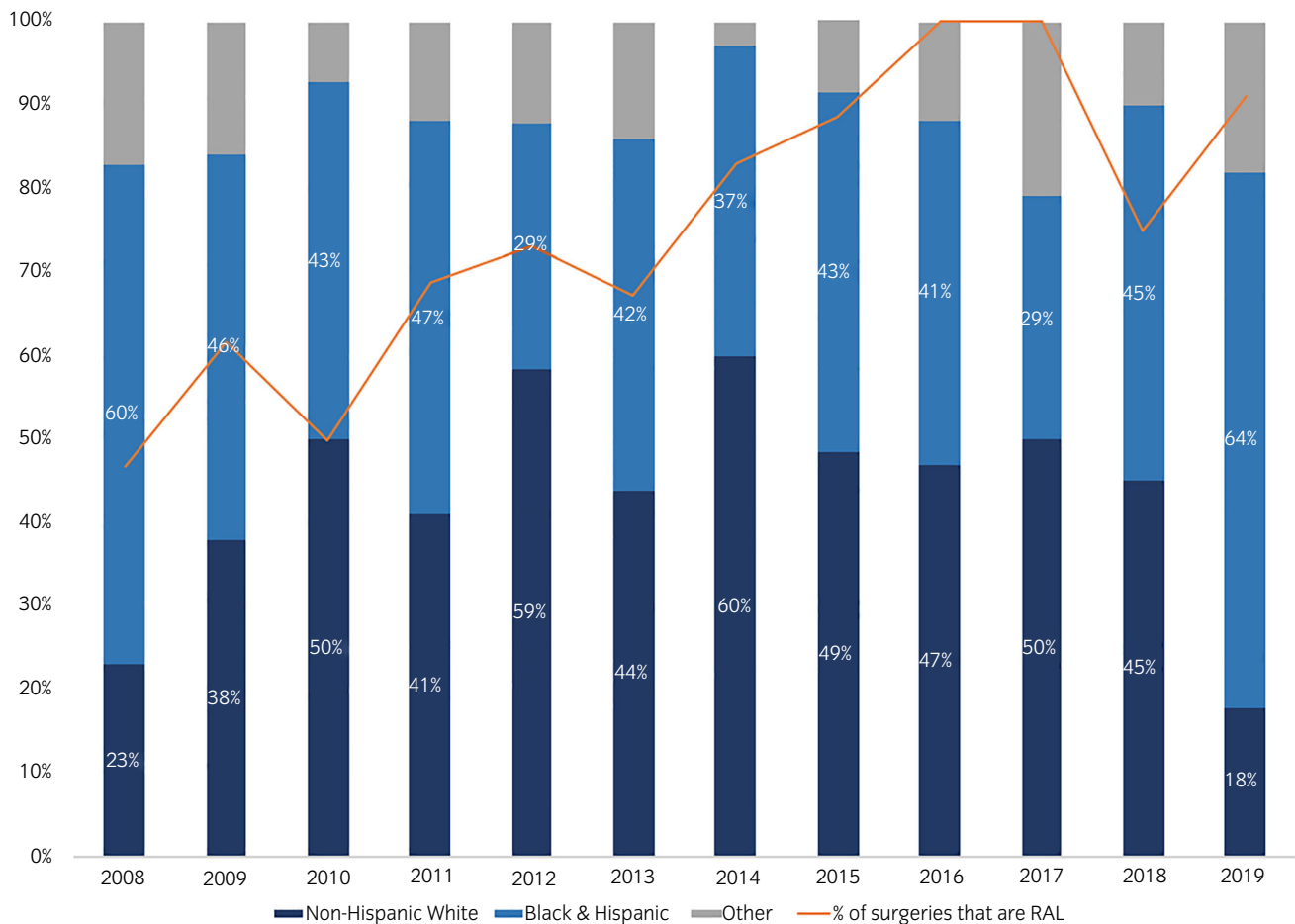
Fig. 2 Race, ethnicity, and RAL surgery by year.

piece of the puzzle. Further investigation of racial distribution among RAL cases with a multi-institutional scope and across different healthcare systems is required to better understand disparities in pediatric urology, an area where sparse literature exists. However, based on literature describing disparities among adult urologic patients, we know that disparities in access to RAL procedures continue to exist and that Black and Hispanic patients are less likely to benefit from advances in medical treatment.[6] Widespread adoption and training in RAL techniques can combat inequity in access to the benefits of RAL surgery, which include but are not limited to decreased operative time, shorter length of hospital stay, and lower complication rates.[15] Ultimately, to provide equitable care and combat health disparities, it is critical that literature, funding, and programming address the effects of systemic racism in healthcare and improve accessibility to quality care. This research provides a foundation for further exploration of this topic both domestically and internationally.

The present study has several limitations, including those inherent to retrospective review. Limitations may have resulted from a database derived from a single tertiary medical center and outcomes based on a single surgeon's experience. Specifically, as a tertiary center, we may attract patient populations that are socioeconomically advantaged. This may confound observed access to RAL procedures

Table 3 Reason for open approach

Reason for open approach	% of open patients
Anatomical complexity	
Bladder exstrophy	1.1
Complex anatomy	6.1
Deflux failure and redo reimplantation	6.1
Large complicated diverticulum reimplantation	4.1
Ectopic ureteral reimplantation	1.0
Obstructive megaureter solitary kidney	6.1
Previous surgery in abdomen	18.4
Solitary kidney reimplantation	7.1
Ureterostomy takedown and reimplantation	8.2
Patient factor (age, comorbidities, patient preference)	5.1
Surgeon RAL learning curve	36.7
Total	100

among our urologic pediatric patients. On the contrary, our patient sample remains highly diverse racially with nearly 43% of patients identifying as either Black or Hispanic. Furthermore, because the studied institution is a large, not-for-profit academic center, any pediatric patient that presents with a medical need will be treated, regardless of resources. Bias may have resulted from patient self-reported

race and ethnicity. Additionally, there may have been an increased rate of open procedures for complex cases at the beginning of the RAL learning curve, which could introduce some bias from the surgeon's perspective. Overall, however, all decisions were made in the best interest of the patient and to optimize results. Surgeons with different training, procedural experience, and patient populations may experience different outcomes. Control variables were utilized in analysis to address bias but not all possible confounders may be accounted for. This methodology is supported by the literature.[2,16]

This study is one of the first to examine socioeconomic disparities in pediatric urology and determined that among pediatric urologic patients at our tertiary care center, there are no statistically significant differences by insurance status or race/ethnicity in pediatric patients undergoing RAL surgery *vs* open surgery. Each year, the racial distribution of patients who underwent surgery by RAL approach did not significantly differ from the racial distribution of patients overall. These findings reinforce that RAL candidacy was determined by case complexity and the surgeon's RAL learning curve and was independent of patient race, ethnicity, and insurance status. This study ultimately calls for further research of disparities in pediatric urology by virtue that it contradicts previous literature and found no racial or socioeconomic disparities in robotic surgery in pediatric urology at our tertiary medical center.

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Author contributions

Amrita Mohanty: Data curation; formal analysis; investigation; writing – original draft; writing – review and editing. Alyssa M Lombardo: Formal analysis; investigation; writing – original draft; writing – review and editing. Clark Judge: Formal analysis; investigation; writing – review and editing. Mohan S Gundeti: Conceptualization; supervision; writing – review and editing.

Conflict of interest

None declared.

Approval of the research protocol by an Institutional Reviewer Board

Approval of the research protocol by an Institutional Reviewer Board: IRB20-0079.

Informed consent

Not applicable.

Registry and the Registration No. of the study/trial

Not applicable.

Animal studies

Not applicable.

References

1 Murphy D, Challacombe B, Khan MS, Dasgupta P. Robotic technology in urology. *Postgrad. Med. J.* 2006; **82**: 743–7.

2 Gabriel E, Thirunavukarasu P, Al-Sukhni E *et al*. National disparities in minimally invasive surgery for rectal cancer. *Surg. Endosc.* 2016; **30**: 1060–7.

3 Kim SP, Boorjian SA, Shah ND *et al*. Disparities in access to hospitals with robotic surgery for patients with prostate cancer undergoing radical prostatectomy. *J. Urol.* 2013; **189**: 514–20.

4 Kim J, El Rayes W, Wilson F *et al*. Disparities in the receipt of robot-assisted radical prostatectomy: between-hospital and within-hospital analysis using 2009-2011 California inpatient data. *BMJ Open*. 2015; **5**: e007409.

5 Monn MF, Bahler CD, Schneider EB *et al*. Emerging trends in robotic pyeloplasty for the management of ureteropelvic junction obstruction in adults. *J. Urol.* 2013; **189**: 1352–7.

6 Xia L, Talwar R, Taylor BL *et al*. National trends and disparities of minimally invasive surgery for localized renal cancer, 2010 to 2015. *Urol. Oncol.* 2019; **37**: 182.e17–27.

7 Illinois Department of Healthcare and Family Services. Affordable Care Act. [Cited 28 Aug 2021.] Available from URL: https://www.illinois.gov/hfs/MedicalClients/AffordableCareAct/Pages/default.aspx

8 Centers for Medicare & Medicaid Services. Percentage of population enrolled in Medicaid or CHIP by State. [Cited 28 Aug 2021.] Available from URL: https://www.medicaid.gov/state-overviews/scorecard/percentage-of-population-enrolled-medicaid-or-chip-state/index.html

9 Masieri L, Sforza S, Grosso AA *et al*. Robot-assisted laparoscopic pyeloplasty in children: a systematic review. *Minerva Urol. Nefrol.* 2020; **72**: 673–90.

10 Masieri L, Sforza S, Grosso AA *et al*. Does the body weight influence the outcome in children treated with robotic pyeloplasty? *J. Pediatr. Urol.* 2020; **16**: 109.e1–6.

11 Masieri L, Sforza S, Cini C *et al*. Minilaparoscopic versus open pyeloplasty in children less than 1 year. *J. Laparoendosc. Adv. Surg. Tech.* 2019; **29**: 970–5.

12 Keisler-Starkey K, Bunch LN. Health insurance coverage in the United States: 2019. 2020. [Cited 26 Aug 2021.] Available from URL: https://www.census.gov/library/publications/2020/demo/p60-271.html

13 Kang EYJ. Chicago neighborhoods continue to shift in size and race. 2019. [Cited 26 Aug 2021.] Available from URL: https://www.npr.org/local/309/2019/06/12/731822220/chicago-neighborhoods-continue-to-shift-in-size-and-race

14 Linares A. Economic development planner. [Cited 26 Aug 2021.] Available from URL: https://greatcities.uic.edu/wp-content/uploads/2019/08/Black-Population-Loss-in-Chicago.pdf

15 Kelz RR, Sellers MM, Niknam BA *et al*. A national comparison of operative outcomes of new and experienced surgeons. *Ann. Surg.* 2021; **273**: 280–8.

16 Andolfi C, Adamic B, Oommen J, Gundeti MS. Robot-assisted laparoscopic pyeloplasty in infants and children: is it superior to conventional laparoscopy? *World J. Urol.* 2020; **38**: 1827–33.