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Identifying variability in surgical practices and instrumentation for hypospadias repair across the Western Pediatric Urology Consortium (WPUC) network

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Extended Summary

Background

Although hypospadias outcomes studies typically report a level or type of repair performed, these studies often lack applicability to each surgical practice due to technical variability that is not fully delineated. An example is the tubularized incised plate (TIP) urethroplasty procedure, the most common hypospadias repair performed worldwide. Modifications of the original TIP have been associated with significantly decreased complication rates in single center series. However, many studies fail to report the use of these modifications such as urethroplasty technique, tissue coverage, or cutoffs for chordee correction, thereby limiting comparison between series.

Objective

With the goal of developing a surgical atlas of hypospadias repair techniques, this study examined 1) current techniques used by surgeons in the Western Pediatric Urology Consortium (WPUC) network for recording operative notes and 2) operative technical details by surgeon for two common procedures, distal TIP and proximal hypospadias repairs across a multi-institutional surgical network.

Study Design

A two-part study was completed. First, a survey was distributed to all members of the network to assess surgeon volume and methods of recording hypospadias repair operative notes. Subsequently, an operative template or a representative de-identified operative note describing a TIP and/or proximal repair with urethroplasty was obtained from participating surgeons. Each was analyzed by at least two individuals for natural language that signified specified portions of the procedure. Procedural details from each note were tabulated and confirmed with each surgeon,

clarifying that the recorded findings reflected their current practice techniques and instrumentation.

Results

Twenty-five surgeons from 12 institutions completed the survey. The number of primary distal hypospadias repairs performed per surgeon in the past year ranged from 1-10 to >50, with 64% (16/25) performing 1-30. Primary proximal hypospadias repairs performed in the past year ranged from 1-30, with 56% performing 1-10. 96% of surgeons maintain operative notes within an electronic health record. 76.5% of the 17 surgeons who routinely use an operative template for hypospadias repair reported that the template captures their operative techniques very or moderately well. Operative notes or templates from 16 surgeons at 10 institutions were analyzed. In 7 proximal and 14 distal repairs, parameters for chordee correction, urethroplasty suture selection and technique, tissue utilized, and catheter selection varied widely across surgeons.

Conclusion

Wide variability in technical surgical details of categorically similar hypospadias repairs was demonstrated across a large surgical network. Surgeon-specific modifications of commonly described procedures are common, and further evaluation of short- and long-term outcomes accounting for these technical variations is needed to determine their relative influence.

Keywords (MeSH terms): hypospadias, reconstructive surgical procedures, urethra, catheters, sutures

Abbreviations: TIP (tubularized incised plate) urethroplasty, Western Pediatric Urology Consortium (WPUC), Polydioxanone (PDS)

Manuscript

Introduction

Hypospadias is classically characterized by proximal displacement of the urethral opening, penile curvature, and a ventrally deficient hooded foreskin. Consistent with its wide range of phenotypic presentation [1], a vast array of surgical approaches have been applied to its repair [2]. In the past decade, there has been an increased reporting of longer-term outcomes associated with each of these described procedures.[3] Despite this, multi-institutional analyses of best technical practices for each type of hypospadias repair remain limited [4]. In many cases, studies lack detail of technical surgical methods and/or the extensive variation between cases and surgeons limit the generation of meaningful data regarding the effect of a single specific technical variant of interest on surgical outcomes.

The reasons for varied surgical techniques applied to named procedural repairs are multi-faceted. Many surgeons note that the greatest early influence in their surgical technique selections was their surgical training and mentors. Over time, personal experience, continuing education, discussions with colleagues, practice setting, and other influences may further lead to adjustments in surgical technique resulting in procedural modifications. Supply chain challenges as occurred during the COVID-19 pandemic and institutional vendor contracts can further account for procedural modifications, particularly in suture, catheter, or dressing selection.[5, 6] Although best practice would be to follow each modification with a formal assessment of resultant effects on short- and long-term outcomes, this does not consistently occur and for rare adverse outcomes seen in a low-volume practice, the effect of such a modification may not be readily apparent. Given this, outlining current techniques used by surgeons across a consortium is necessary to inform future database development and to ensure the relevance of resultant reported outcomes.

We hypothesized that wide technical variability exists— particularly in the urethroplasty and glansplasty portions of hypospadias repairs. With the eventual goal of developing a surgical atlas of hypospadias repair techniques, this study examined 1) current techniques used by surgeons in our network for recording operative notes and 2) operative technical details by surgeon for two common procedures, distal TIP and proximal hypospadias repairs. This work is the first to analyze an array of surgical techniques and tissue utilization in hypospadias repair operative notes and templates across a broad multi-institutional surgical network of pediatric urologists.

Material and Methods

A two-part study was completed. First, a survey was distributed to the Western Pediatric Urology Consortium (WPUC) network to assess surgeon volume and methods of recording hypospadias repair operative notes. At the time of the study WPUC had 19 centers involved in the consortium, including three in Canada, two in the eastern United States, and the remaining in the western United States. The survey was emailed 43 participating surgeons in the network, with three reminders while open for accrual between January 2021 to May 2021 via Qualtrics. The survey consisted of 22 questions created *de novo* regarding demographics of respondents, hypospadias repair volume, operative template management, and electronic health record (EHR) usage. Only responses from practicing fellowship trained surgeons who perform hypospadias repair were included.

Subsequently, an operative template or a representative de-identified operative note describing a primary TIP and/or proximal repair with urethroplasty was obtained from participating WPUC surgeons. The surgeons who submitted a prior survey were also invited to send in an operative note template. Each surgeon emailed these de-identified notes or templates to

the senior author. Each template or note was analyzed for linguistic identifiers that signified specified portions of the procedure. The linguistic identifiers were focused on type of repair, suture type, needle, and technique for each layer of the urethroplasty and glansplasty, tissue selection for the urethroplasty and secondary coverage, completion of an artificial erection and its description, and type of curvature assessment, and urethral catheter selection, equaling a total of ~~12~~ 16 unique identifier categories. Two medical professionals reviewed each note including at a minimum one fellowship-trained board-certified pediatric urologist, with consensus achieved as to which identifiers were present in the template or note. Procedural details from each note were tabulated and subsequently confirmed with each surgeon who submitted a note, clarifying that the recorded findings reflected their most common techniques for each procedure in their current practice. This study was submitted to the UCLA IRB for review and was deemed exempt (IRB#21-000800).

Data analysis used Microsoft Excel (Version 2110). Each data element mentioned above was documented and compared across the different operative templates to calculate frequency and variability per element. In discussion with each surgeon, the findings from each template were verified, with recording of accuracy and completeness of each template or operative note reviewed for each specified data element.

Results

In the first portion of the study, 25 surgeons from 12 institutions completed the survey in its entirety except for questions not provided due to branching logic when applicable. All 25 reported that 100% of their practice is dedicated to the care of children (<18 years of age). Fifty-two percent (13/25) of the respondents have been in practice 0-10 years following completion of post-graduate surgical training (Table 1). 36% (9/25) reported that their practice currently

maintains a hypospadias registry. The number of primary distal hypospadias repairs performed per surgeon in the past year ranged from 1-10 to >50, with 64% (16/25) performing 1-30. Primary proximal hypospadias repairs performed in the past year ranged from 1-30, with 56% (14/25) performing 1-10 (Table 1). The initial date when operative notes were first documented electronically in each respective hospital system ranged between 1994-2018 with the majority initiated between 2001-2012 (70.8%). Ninety-six percent (24/25) of surgeons currently maintain operative notes within an EHR. 17/25 surgeons (68%) reported use of operative templates to record the details of their hypospadias repairs. Table 2 displays the responses of these 17 surgeons. Most notably, 76.5% (13/17) of surgeons who use operative templates reported that their current templates capture their operative techniques very or moderately well.

In the second part of the study, operative templates (n=17) or de-identified notes (n=4) from 16 surgeons at 10 institutions were analyzed. This included 14 TIP and 7 proximal hypospadias repairs. Language used to signify variables of interest was collated in the Supplemental Table. Data elements for both TIP and proximal hypospadias repairs were reported in Table 3A-C.

Specific to TIP operative templates/notes, when tubularizing the urethral plate 6 surgeons typically completed a one-layer urethroplasty and 8 a two-layer urethroplasty. The most common suture techniques for the first or single layer (when only one is completed) was a subepithelial/subcuticular placement (12/14) and a running technique (9/14) versus simple (2/14) and interrupted (5/14) technique, respectively. 7-0 Polyglactin (Vicryl) (5/14) was the most common suture used for the first/single layer. The 8 templates that reported a two-layer urethroplasty were equally divided between use of a running or an interrupted suture technique for

the second layer. Suture selection for this layer reflected that of the first/single layer. 12/14 surgeons routinely used dartos secondary coverage (Table 3A).

Eighty-six percent of surgeons (12/14) ‘always’ or ‘most of the time’ performed an artificial erection after degloving before urethroplasty when completing a TIP. Of note, 57% (8/14) estimated the curvature degree visually; 36% (5/14) used a goniometer. When asked the maximum curvature that did not require further correction after degloving, there was considerable variability with the most common thresholds being 10 (5/14) and 15 (5/14) degrees. The maximum curvature in degrees accepted after plication without further correction was 30 (1/14) (Table 3B).

Six of the proximal hypospadias repair templates/notes recorded a two-stage preputial graft repair and one a single stage preputial onlay repair. The first layer suture technique was approximately evenly split between simple versus subepithelial/subcuticular placement and running versus interrupted technique, respectively. There was wide variability in suture selection, with 5-0 and 6-0 PDS being the most common. Interrupted (5/7) suture technique was the most common selection for closure of the second layer. Secondary tissue coverage applied dartos tissue (4/7) or tunica vaginalis (2/7), with one surgeon reporting no secondary coverage.

Eighty-six percent (6/7) of surgeons ‘always’ performed an artificial erection test during a proximal hypospadias repair. Most used a tourniquet (6/7) for this test. For curvature measurement, 4/7 used eyeball, 2/7 a goniometer, and 1/7 an angle meter application on a mobile device. The maximum curvature in degrees accepted without further correction after degloving was higher than that seen in distal hypospadias, but varied widely from 0 (2/7) to 30 (1/7). After plication, the maximum curvature accepted also ranged from 0 (2/7) to 30 (1/7) (Table 3B).

A glansplasty was reported in all operative templates/notes. For the subepithelial layer, a simple interrupted or U-stitch was the most common used in our cohort, reported in 9/14 TIP and

5/7 proximal repairs versus a mattress stitch, most commonly using a 6-0 PDS (7/14 TIP, 3/7 proximal). 50% placed epithelial sutures in the glans during a TIP repair, of which 6 reported a simple interrupted and 1 a mattress technique. Most proximal repairs also included placement of epithelial glans sutures, with 3 using a simple interrupted and 2 a mattress stitch (Table 3C).

Catheter selection for both TIP and proximal hypospadias repair varied widely, including catheters, feeding tubes, and stents with 6 urethroplasties completed over a larger entity for tubularization (Table 3A).

Discussion

Across pediatric fellowship trained urologic surgeons and institutions, remarkable variability in surgical techniques, tissue selection, and suture selection exists in categorically similar hypospadias repair procedures. This study provides a snapshot of hypospadias surgical repairs across the largest number of surgeons to date in our field, thereby documenting this variability. These research findings highlight the need for improved granularity in reporting of surgical technical details as even categorically similar procedures (e.g., TIP) varied extensively in tissue layers, surgical technique, and instrumentation. The provision of surgical details abstracted from operative notes can assist researchers in building relevant databases that will include key areas of variability for future outcomes analyses. Additionally, this study demonstrates the potential efficacy of surgical template analysis across institutions as a method to create a surgical procedural atlas for complex technical reconstructive procedures.

More than 300 hypospadias repair techniques have been published,[7] with modifications of common procedures expanding the repertoire from which a surgeon selects a technique for a given patient. Reflecting both published and unpublished repair options, the surgeons in our study

displayed a wide range of technical selections when providing details of their most commonly utilized standard techniques for TIP and proximal hypospadias repairs, respectively. Technical details observed to have the most evident variation between our surgeons included parameters for chordee evaluation and correction, urethroplasty suture selection and technique, tissue coverage, and catheter selection.

When reported, currently published literature provides conflicting results as to the effects of these individual technical details. There are multiple reasons for this, including the limitations of single center or surgeon series, uncaptured variations in multiple aspects of repairs across surgeons, and varied outcomes reporting. An example specific to the TIP urethroplasty portion is that small series have demonstrated conflicting results regarding lower complication rates with the use of PDS versus vicryl, rapid-absorbing suture, and/or interrupted versus continuous closure techniques.[8-13] Snodgrass and Bush have reported a decrease in fistula occurrence when adjusting from a simple to subepithelial urethroplasty, further enhanced by modifications of urethroplasty tissue coverage[14, 15]. Similarly, a recent meta-analysis reported a potential benefit to tunica vaginalis urethroplasty coverage versus dartos alone[16]. As the present study highlights, extensive variability exists and requires future investigation to elucidate the role that each aspect of suture, technique, and tissue coverage may have in surgical outcomes.

Beyond the urethroplasty, the surgeons in our series also reported variability in preferred glansplasty and chordee analysis techniques. Literature examining technical details of the glansplasty vary in reports of efficacy between single versus double-layered closures,[17] the depth of suture placement to minimize both stricture and dehiscence, the use of epithelial sutures, and suture selection [20]. As for the chordee analysis, surgeons in our series commonly perform an artificial erection post-degloving in either TIP or proximal hypospadias repairs. However, when

surgeons provided details regarding chordee degree analysis, and cutoffs indicating a need for correction, these varied widely. Despite the strong association that has been demonstrated between ventral curvature and surgical complications such as dehiscence and fistula development,[18] no standardized cutoff for adequate chordee correction or method of measurement of that angle exists.[19] Our series highlights the need for evaluation of the technique for chordee analysis and the effects of varied decision-making pathways for chordee correction in future studies.

Finally, in our series there is wide variability in urethral catheter/stent selection, though most urologists reported routine use of postoperative urinary diversion for both TIP and proximal procedures. When used, all reported that they most commonly place a catheter within the urethra that extends to the bladder, as opposed to a suprapubic tube or an anterior urethral stent. This aligns with findings that an anterior urethral stent alone may increase complication rates; however, it does not account for the potential for a lower fistula rate with suprapubic catheterization [20]. Furthermore, another series has demonstrated higher fistula rates following urethral catheter usage as compared to a feeding tube[21] though a variety of selections across a wide margin of mechanical characteristics were used in our series [22]. Put together, the impact that varied postoperative drainage and/or its use itself is poorly defined; these variations in catheter selection should be provided in future outcomes reporting.

Over 75% of surgeons in WPUC who participated in this network-wide survey (Study Part 1) stated that operative templates capture their operative techniques very or moderately well. These responses provided an initial validation prior to proceeding to the next stage of our project. A subset of surgeons who participated in the survey elected to participate in provision of operative templates or a representative de-identified note (Study Part 2). For further validation that the data collected from these notes was an accurate reflection of current surgical practice, each surgeon

who participated in Study Part 2 reviewed the data obtained by the research team and clarified or edited any elements as needed to reflect their current 'most common' practice. We found overall that the operative templates were accurate and reflected current techniques by surgeon, with few clarifications required. However, completeness varied, with approximately 75% of the data points present, with the most common missing data point being suture technique. Put together, templates may be an accurate method to expand surgical details used across a network in a retrospective study. However, creating standardized templates to collect all variables of interest or establishing standardized methods of analyzing videotaped or observed surgical technique by procedure are needed to ensure consistent capture in a prospective fashion.[23]

This was an initial analysis to collect variables that may will inform future studies and database development. As such, several limitations warrant consideration. First, the surgeons surveyed were all part of the same multi-institutional network and most were clustered geographically which could influence reported surgical techniques and affect surgical variability. Second, recall and response bias could affect the operative details that were provided in verification of the 'most common' practice of each surgeon. Lastly, this study does not identify which aspects of variability may affect surgical outcomes. It also does not analyze the interplay between technical selections for each aspect of the procedure. Such technical selections may or may not directly affect surgical outcomes alone and in part may reflect surgeon experience as well as the extensive phenotypic range reflected by children with hypospadias.

This study provides technical selections for key aspects of hypospadias repairs in the largest number of surgeons to date across a multi-institutional network. This work can inform future clinical and translational research as surgeons seek to optimize their technical selection for each patient and to analyze the potential effects of each technical aspect of these repairs. Further,

it highlights the need for detailed reporting of surgical techniques that correspond to hypospadias outcomes reporting and creates an atlas for potential areas in which such data collection is needed. From this study, it is evident that one surgeon's TIP is not equal to another surgeon's TIP. Future directions include both retrospective and prospective data collection. Retrospectively, the linguistic elements collected can inform natural language processing (NLP) algorithms developed to rapidly evaluate operative notes in an automated fashion. Prospectively, this data can also inform database and standardized template development, thereby improving consistency of data capture for future outcomes studies. Additionally, for technical aspects known to affect operative outcomes, these parameters can inform education such that the minimum required surgeon fellowship training should include learning these data-driven technical aspects of hypospadias repair. This study is an example of the power of broad network participation as seen in pediatric urology consortiums [24] that have led the way in defining current challenges and opportunities within the field of pediatric urology.

Conclusion

To our knowledge, this is the first study to analyze the variability of surgical techniques and tissue utilization in hypospadias repair across a large surgical network of pediatric urologist. There was wide variability across the network in the tissue layers, suture types, suture techniques, and catheters utilized during the artificial erection, urethroplasty, and glansplasty portions of both distal and proximal hypospadias repairs. This project is a first step toward creation of a comprehensive atlas of descriptive terminology and techniques used in hypospadias repair. Additionally, data gleaned from this study is needed to inform variables for future surgical studies of hypospadias outcomes.

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Survey Responses	n (%)
How many years have you been in practice following completion of post-graduate surgical training?	
0-10	13 (52)
11-20	7 (28)
21-30	3 (12)
>30	2 (8)
How many primary distal hypospadias repairs have you performed in the past year?	
1-10	3 (12)
11-30	13 (52)
31-50	7 (28)
>50	2 (8)
How many primary proximal hypospadias repairs have you performed in the past year?	
1-10	14 (56)
11-20	10 (40)
21-30	1 (4)
>30	0

Table 1. Surgeon responses to demographic survey questions.

Survey Responses	n (%)
How many operative templates do you currently use for hypospadias repair?	
None	8 (32)
1-4	15 (60)
>5	2 (8)
How well does the template capture your current practice?	
Very or moderately well	13 (76.5)
Neither well nor poorly	3 (17.6)
Moderately poorly	1 (5.9)
How did you obtain the initial templates that you currently use?	
Created 'de novo'	12 (70.6)
Edited another surgeons' template	4 (2.35)
Other	1 (5.9)
When was the last time you personally edited one of your operative templates for hypospadias repairs to reflect your practice more closely?	
In the past 12 months	13 (76.5)
1-5 years	4 (23.5)
>5 years	0

Table 2. Surgeon responses to questions concerning operative templates.

Urethroplasty	**Tubularized Incised Plate (n=14)**		**Proximal Hypospadias Repair (n=7, 1 single, 6 second stage)**	
Variable	*Selection*	*n*	*Selection*	*n*
Technique-First/Single Layer	Simple	2	Simple	4
	Subepithelial	12	Subepithelial/ subcuticular	3
	Running	9	Running	4
	Interrupted	5	Interrupted	3
Suture Type	7-0 Vicryl	5	7-0 Vicryl	1
	7-0 Polysorb	1	6-0 Polysorb	1
	7-0 Maxon	1	7-0 Maxon	1
	6-0 PDS	3	5-0 or 6-0 PDS	3
	7-0 PDS	4	7-0 PDS	1
Technique-Second layer	Running	4	Running	2
	Interrupted	4	Interrupted	5
	None	6		
Suture Type	7-0 Vicryl	3	7-0 Vicryl	1
	7-0 Maxon	1	7-0 Polysorb	1
	6-0 PDS	2	7-0 Maxon	1
	7-0 PDS	2	5-0 or 6-0 PDS	3
			7-0 PDS	1
Secondary tissue coverage	Dartos alone	8	Dartos	4
	Dartos AND spongiosum	4	Tunica Vaginalis	2
	Spongiosum alone	2	None	1
Catheter at case conclusion				
Urethral catheter	8F Feeding tube	2	8F Foley	2
	8F Folysyl foley catheter	1	8F Koyle	1
	8F Zaontz	1	7F Round drain	2
	8F Silastic urethral stent	1	6F Feeding tube	2
	7F Round drain	5		
	6F/8F Koyle stent	2		
	6F Feeding tube	1		
	6F Kendall catheter	1		

Table 3A. Urethroplasty data elements extracted from operative templates/notes, with surgeon verification.
Notes: no catheter if age <12mo (1 surgeon), 6F tubularize over an 8F (2), 7F over a 10F (4).

Chordee	**Tubularized Incised Plate (n=14)**		**Proximal Hypospadias Repair (n=7)**	
Artificial Erection				
Variable	*Selection*	*n*	*Selection*	*n*
Frequency Performed (≥1)	Always	7	Always	6
	Most of the time	5	Most of the time	1
	Sometimes	2		
Tourniquet Use	Yes	9	Yes	6
	No	4	No	1
	Other/Both	1		
Injection Agent	Injectable Saline	13	Injectable Saline	7
	Lactated Ringer	1		
Angle Assessment Method	Eyeball	8	Eyeball	4
	Goniometer	5	Goniometer	2
	Angle meter app	1	Angle meter app	1
Adequate chordee correction				
Timing	*Degrees*	*n*	*Degrees*	*n*
After degloving	Zero	3	Zero	2
	Five	1	Ten	1
	Ten	5	Fifteen	2
	Fifteen	5	Twenty	1
			Thirty	1
After plication	Zero	3	Zero	2
	Five	3	Five	1
	Ten	3	Fifteen	2
	Fifteen	4	Thirty	1
	Thirty	1	Not applicable	1

Table 3B. Artificial erection and chordee assessment data elements extracted from operative templates/notes, with surgeon verification.

Glansplasty	**Tubularized Incised Plate (n=14)**		**Proximal Hypospadias Repair (n=7)**	
Variable	*Selection*	*n*	*Selection*	*n*
Technique-Subepithelial Layer	Simple interrupted or U-stitch	9	Simple interrupted or U-stitch	5
	Mattress or Zucker (1)	5	Mattress	2
Suture Type	5-0 Vicryl	1	5-0 Vicryl	1
	6-0 Vicryl	1	6-0 Polysorb	1
	6-0 Polysorb	1	6-0 Maxon	1
	6-0 Maxon	1	5-0 PDS	1
	4-0 or 5-0 Plain gut	1	6-0 PDS	3
	5-0 Monocryl	1		
	6-0 Monocryl	1		
	6-0 PDS	7		
Technique-Epithelial Layer	Simple interrupted	6	Simple interrupted	3
	Mattress	1	Mattress	2
	None	7	None	2
Suture Type	7-0 Vicryl	1	5-0 Vicryl rapide	1
	8-0 Vicryl	1	8-0 Vicryl	1
	6-0 Monocryl	1	6-0 Chromic	1
	6-0 PDS	2	6-0 PDS	1
	7-0 PDS	2	7-0 PDS	1

Table 3C. Glansplasty data elements extracted from operative templates/notes, with surgeon verification.