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Authors

Johnsen, Niels Vass
Moses, Rachel A
Elliott, Sean P
et al.

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ORIGINAL ARTICLE

Multicenter analysis of posterior urethroplasty complexity and outcomes following pelvic fracture urethral injury

Niels Vass Johnsen[1,11] · Rachel A. Moses[2] · Sean P. Elliott[3] · Alex J. Vanni[4] · Nima Baradaran[5] · Garrick Greear[6] · Thomas G. Smith III[7] · Michael A. Granieri[8] · Nejd F. Alsikafi[9] · Bradley A. Erickson[10] · Jeremy B. Myers[2] · Benjamin N. Breyer[5] · Jill C. Buckley[6] · Lee C. Zhao[8] · Bryan B. Voelzke[1] · For the Trauma Urologic Reconstruction Network of Surgeons(TURNS)

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Abstract

Purpose To analyze outcomes of posterior urethroplasty following pelvic fracture urethral injuries (PFUI) and to determine risk factors for surgical complexity and success.

Methods Patients who underwent posterior urethroplasty following PFUI were identified in the Trauma and Urologic Reconstructive Network of Surgeons (TURNS) database. Demographics, injury patterns, management strategies, and prior interventions were evaluated. Risk factors for surgical failure and the impact of ancillary urethral lengthening maneuvers (corporal splitting, pubectomy and supracrural rerouting) were evaluated.

Results Of the 436 posterior urethroplasties identified, 122 were following PFUI. 83 (68%) patients were acutely managed with suprapubic tubes, while 39 (32%) underwent early endoscopic realignment. 16 (13%) patients underwent pelvic artery embolization in the acute setting. 116 cases (95%) were completed via a perineal approach, while 6 (5%) were performed via an abdominoperineal approach. The need for one or more ancillary maneuvers to gain urethral length occurred in 4 (36%) patients. Of these, 44 (36%) received corporal splitting, 16 (13%) partial or complete pubectomy, and 2 (2%) supracrural rerouting. Younger patients, those with longer distraction defects, and those with a history of angioembolization were more likely to require ancillary maneuvers. 111 patients (91%) did not require repeat intervention during follow-up. Angioembolization ($p=0.03$) and longer distraction defects ($p=0.01$) were associated with failure.

Conclusions Posterior urethroplasty provides excellent success rates for patients following PFUI. Pelvic angioembolization and increased defect length are associated with increased surgical complexity and risk of failure. Surgeons should be prepared to implement ancillary maneuvers when indicated to achieve a tension-free anastomosis.

Keywords Pelvic fracture urethral injury · Posterior urethroplasty · Urotrauma · Urethral stricture · Angioembolization · Distraction defect

✉ Niels Vass Johnsen
nielsvj@uw.edu; njohnsen@gmail.com

[1] Departments of Urology, University of Washington, Seattle, WA, USA

[2] University of Utah, Salk Lake City, UT, USA

[3] University of Minnesota, Minneapolis, MN, USA

[4] Lahey Hospital and Medical Center, Burlington, MA, USA

[5] University of California San Francisco, San Francisco, CA, USA

[6] University of California, San Diego, USA

[7] Baylor College of Medicine, Houston, TX, USA

[8] New York University, New York, NY, USA

[9] Uropartners, Gurnee, IL, USA

[10] University of Iowa (BAE), Iowa City, IA, USA

[11] Harborview Medical Center, Box 359868, 325 Ninth Ave, Seattle, WA 98104, USA

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Introduction

Posterior urethral reconstruction following pelvic fracture urethral injury (PFUI) remains a technically difficult urologic operation. First described by Webster in 1983, a perineal approach involving urethral mobilization augmented by progressive maneuvers to gain urethral length has become standard practice [1]. Ancillary maneuvers beyond urethral mobilization are sequentially approached, progressing from corporal splitting to partial or complete pubectomy to supracrural rerouting, with each additional step aiming to increase urethral mobility but also increasing surgical complexity.

There exists significant variability within the literature as to the need for ancillary maneuvers during posterior urethroplasty and the association of these maneuvers with surgical success [2–6]. Likewise, the impact of initial injury management strategies and other perioperative variables on urethral reconstruction complexity and success is controversial. The primary aim of the present study is to provide a multi-institutional analysis of outcomes following posterior urethroplasty for PFUI and, secondly, to analyze the impact of preoperative and intraoperative factors on surgical complexity and success.

Methods

Men treated between January 1, 2008 and September 1, 2017 with posterior urethroplasty at 10 participating TURNS (Trauma and Urologic Reconstruction Network of Surgeons) member institutions were retrospectively identified. TURNS is a multi-institutional surgical outcomes group that prospectively collects perioperative and longitudinal data on reconstructive urological disease. Only patients with a history of traumatic pelvic fracture were included. Institutional review board approval was previously obtained at all participating institutions.

Particulars of operative technique varied among providers but adhered to standard agreed upon principles [7]. The anterior urethra was mobilized circumferentially and a urethral sound or catheter passed to identify the location of the distraction defect. The urethra was then transected at the level of obstruction and all fibrotic tissue completely excised. The urethral ends were spatulated and anastomosed using absorbable suture. Surgeon discretion determined the need for ancillary maneuvers to obtain proximal exposure and a tension-free anastomosis, as well as any alterations in surgical approach. Progression of ancillary maneuvers in all cases was from corporal splitting to pubectomy (partial or complete) to corporal splitting.

Patient demographics including age at the time of urethroplasty, body mass index (BMI), the presence of diabetes mellitus (DM), and history of prior urologic procedures were collected. Acute injury characteristics including pelvic fracture patterns and initial urethral injury management strategy (endoscopic realignment versus suprapubic tube [SPT]), as well as whether pelvic artery angioembolization was performed, were compiled to determine impact on intraoperative and postoperative outcomes.

Intraoperative variables analyzed included surgeon-estimated distraction defect length, operative approach (perineal or abdominoperineal), use of ancillary maneuvers, lithotomy position time, and total operative time. Follow-up generally consisted of uninstrumented uroflowmetry and post-void residual measurements at 3 and 12 months, with cystoscopy performed at 3 months or earlier if symptomatic. Failure was defined as the need for further interventions for symptomatic urethral stenosis. For those who experienced failure, time to failure and interventions required were evaluated. Statistical analysis was performed using R statistical software (Vienna, Austria). Normally distributed variables were described with means and standard deviations (SD) and compared with the Student t test or ANOVA, as appropriate. Skewed variables were described with medians and interquartile ranges (IQR) and compared using the Mann–Whitney U test or Kruskal–Wallis test, as appropriate. Holm's method for multiple comparisons was utilized for post hoc testing. Categorical variables were compared using the Fisher exact test. All statistical tests were two sided with a p value of less than 0.05 considered statistically significant.

Results

Demographics and acute management

Of the 436 men identified who underwent posterior urethroplasty, 122 (28%) were due to traumatic PFUI and included. Median follow-up was 7.0 months (IQR 3.2–18.7). Mean patient age was 41.6 years (SD 16.2) with a mean BMI of 25.9 (SD 6). Eleven (9%) had a prior urethroplasty and 23 (19%) had a prior endoscopic intervention for urethral stenosis following PFUI (Table 1). Eighty-three patients (68%) were managed initially with SPT placement, while 39 (32%) underwent endoscopic realignment. Sixteen patients (13%) had pelvic artery angioembolization for associated vascular injuries at presentation, of which eight (50%) had bilateral embolizations.

Intraoperative details

Mean operative time was 241 (SD 103) minutes, with a mean lithotomy time of 226 (SD 89) minutes. Median estimated

Table 1 Patient, preoperative and intraoperative risk factors associated with success of posterior urethroplasty following pelvic fracture urethral injuries

	Total	Success	Failure	*p* value
Patients (*n*, %)	122	111 (91.0)	11 (9.0)	
Mean age, years (SD)	42 (16.2)	42 (15.8)	37 (20.1)	0.32
Mean BMI (SD)	25.9 (5.9)	26.1 (5.9)	23.7 (6.3)	0.19
Diabetic (*n*, %)	8 (6.6)	7 (6.3)	1 (9.1)	0.54
Prior endoscopic treatment (*n*, %)	23 (18.9)	22 (19.8)	1 (9.1)	0.69
Prior urethroplasty (*n*, %)	11 (9.0)	10 (9.0)	1 (9.1)	1.00
Angioembolization (*n*, %)	16 (13.1)	12 (10.8)	4 (36.4)	0.04
Unilateral	8 (6.6)	5 (4.5)	3 (27.3)	
Bilateral	8 (6.6)	7 (6.3)	1 (9.1)	
Acute urethral management (*n*, %)				0.50
Realignment	39 (32.0)	37 (33.3)	2 (18.2)	
SPT	83 (68.0)	74 (66.7)	9 (81.8)	
Median estimated defect length, cm (IQR)	2.0 (1.5–3.0)	2.0 (1.5–2.7)	3.0 (2.1–3.5)	0.01
Operative approach (*n*, %)				0.09
Perineal	116 (95.1)	107 (96.4)	9 (81.8)	
Abdominoperineal	6 (4.9)	4 (3.6)	2 (18.2)	
Ancillary maneuvers (*n*, %)				
Any	44 (36.1)	39 (35.1)	5 (45.5)	0.52
Corporal splitting	44 (36.1)	39 (35.1)	5 (45.5)	1.0
Partial or complete pubectomy	16 (13.1)	13 (11.7)	3 (27.3)	0.16
Supracrural rerouting	2 (1.6)	2 (1.8)	0	1.0

BMI body mass index, *IQR* interquartile range, *SD* standard deviation, *SPT* suprapubic tube

distraction defect length was 2.0 cm (IQR 1.5–3.0). One hundred and sixteen cases (95%) were completed via a perineal approach alone, while 6 (5%) required an abdominoperineal approach. As compared to those who underwent perineal repair, patients who underwent abdominoperineal repairs had longer distraction defects (median 4.0 vs 2.0 cm, $p < 0.001$), but were otherwise similar.

Direct anastomosis with scar excision and urethral mobilization alone was performed in 78 patients (64%). 44 patients (36%) underwent one or more ancillary reconstructive maneuvers at the time of urethroplasty. Of these, corporal splitting was employed in 44 patients (36%), partial inferior pubectomy in 13 (11%), complete pubectomy in 3 (2%), and supracrural rerouting in 2 (2%). Patients requiring 2 or more ancillary maneuvers tended to be younger and have longer distraction defects than those who did not. On post hoc analysis adjusting for multiple comparisons, defect lengths in patients not requiring ancillary procedures differed significantly from both those requiring 1 and ≥ 2 procedures (adjusted p values 0.008 and 0.01, respectively). There was no significant difference in defect length between those requiring 1 and ≥ 2 ancillary procedures ($p = 0.62$). A history of angioembolization was significantly associated with the need for multiple ancillary maneuvers (Table 2).

All 6 patients who underwent abdominoperineal repair were acutely managed with SPT placement, although this association did not reach statistical significance ($p = 0.18$). While need for corporal splitting did not differ between patients who underwent endoscopic realignment and those managed with a SPT (32% vs 38%, $p = 0.55$), SPT managed patients were more likely to require pubectomy (3% vs 17%, $p = 0.04$). Both patients who underwent supracrural rerouting were managed with a SPT. There was no difference in median estimated distraction defect length (2.0 vs 2.0, $p = 0.61$), mean operative time (217 vs 249 min, $p = 0.10$), mean lithotomy time (211 vs 230 min, $p = 0.25$), or overall success (91% vs 95%, p = 0.72) between endoscopic realignment and SPT patients, respectively.

Overall success

At last follow-up, overall success was 91%. Median time to failure for the 11 failures was 5.4 months (IQR 3.3–7.9). Failures were treated with endoscopic means (direct vision internal urethrotomy or urethral dilation) in 7 (64%) patients and repeat urethroplasty in 4 (36%) patients. While an abdominoperineal approach neared statistical significance ($p = 0.09$), only angioembolization at the time of the original trauma ($p = 0.04$) and increased distraction defect length ($p = 0.01$) were significantly associated with an increased risk of failure (Table 1).

Table 2 Impact of patient and preoperative factors on number of ancillary maneuvers required during posterior urethroplasty and surgical success

	Number of ancillary maneuvers			
	0	1	≥ 2	*p*-value
Patients (*n*, %)	77 (63.1)	28 (23.0)	17 (13.9)	
Mean age, years (SD)	44.6 (15.3)	38.8 (17.8)	32.1 (13.3)	0.006
Mean BMI (SD)	26.7 (6.0)	26.0 (5.9)	22.4 (4.5)	0.31
Prior endoscopic treatment (*n*, %)	13 (16.9)	8 (28.6)	2 (11.8)	0.29
Prior urethroplasty (*n*, %)	7 (9.1)	2 (7.1)	2 (11.8)	0.81
Angioembolization (*n*, %)	9 (11.7)	1 (3.6)	6 (35.3)	0.01
Acute urethral management (*n*, %)				0.16
Realignment	27 (35.1)	10 (35.7)	2 (11.8)	
SPT	50 (64.9)	18 (64.3)	15 (88.2)	
Median estimated defect length, cm (IQR)	2.0 (1.5–2.5)	2.5 (2.0–3.0)	3.0 (2.0–3.5)	0.001
Success (*n*, %)	71 (92.2)	26 (92.9)	14 (82.4)	0.38

BMI body mass index, *IQR* interquartile range, *SD* standard deviation, *SPT* suprapubic tube

Discussion

In the present study, we analyzed the impact of a number of preoperative and perioperative variables to better define factors associated with requiring advanced ancillary maneuvers during posterior urethroplasty following PFUI and to determine the impact that these maneuvers have on surgical outcomes. A history of angioembolization and longer distraction defects were found to be significantly associated with urethroplasty failure. Furthermore, while the majority of cases were completed with urethral mobilization alone, over one-third of patients required 1 or more ancillary maneuvers to achieve a tension-free anastomosis, with supracrural rerouting almost never utilized in our cohort.

Acute management

The impact of acute urethral injury management strategies on urethroplasty complexity and success has previously been explored. Both Koraitim and Fu et al. found that patients who were realigned had shorter fibrotic defects and required less complex urethroplasties [8, 9]. In the present study, we found no statistically significant differences in estimated distraction defect length, operative time, or overall success between realigned patients and SPT patients. However, patients managed initially with SPT alone were more likely to require inferior pubectomy. Although not statistically significant, all patients who underwent abdominoperineal repairs, as well as both patients who had supracrural rerouting, were similarly managed with SPT. While it is likely that this is in large part due to the severity of injury experienced (i.e., patients with more severe pelvic and urethral injuries were less likely be realigned), these findings are not dissimilar to those recently published by Zou et al., who found that patients who underwent urethral realignment were less likely to require ancillary maneuvers [10]. The decision to attempt realignment is often based on individual provider preferences and injury characteristics, as well as those of coordinating orthopedic surgeons [11]. However, long-term follow-up of realigned patients has found a stenosis-free survival rates as low as 9%, as well as raised concerns regarding delays in definitive treatment [12–14]. A prospective, multi-institutional trial is currently underway to provide a better assessment of the outcomes and impact of urethral realignment as compared to SPT for PFUI patients [15].

The impact of pelvic vascular injury management has not been well evaluated prior to the current study. We found that a history of pelvic angioembolization at the time of injury was a significant risk factor for surgical failure. While this is the first study to document this risk, arterial insufficiency has previously been identified as a risk factor for failure and some have advocated using preoperative penile Doppler ultrasound assessment in high-risk patients to evaluate arterial integrity and potential need for penile revascularization prior to urethroplasty [16–20]. While the data presented here do show that angioembolization is associated with an increased rate of urethroplasty failure, the present study did not specifically assess the role of preoperative Doppler assessment or revascularization in predicting failures. Furthermore, angioembolization may be a surrogate marker for more severe pelvic injuries overall, which may result in worse fibrosis, longer defects and more substantial tissue injury that impact surgical success.

Prior urethral interventions

The impact of prior urethral interventions on urethroplasty outcomes is unclear. Culty et al. evaluated 51 patients and found that patients with a history of prior urethral surgery (either endoscopic or open) had significantly lower success relative to those who did not (60% vs 90%, respectively) [21]. Singh et al. similarly evaluated 58 patients and found

that a history of prior urethroplasty or prior attempts at urethral realignment significantly decreased urethroplasty success rates, while up to 2 prior endoscopic interventions did not [22].

In the current study, prior urethral intervention was not found to negatively impact urethroplasty success. While there is concern that urethral manipulation can lead to increased inflammation and fibrosis, our experience has not identified a quantifiable difference in terms of surgical complexity, duration, or success [23]. However, repeated endoscopic interventions have been shown to have a low likelihood of success, high costs and potential prolongation of time to successful treatment [13, 14, 24]. As such, we do not believe that repeated endoscopic interventions are warranted for these reasons [25].

Surgical approach and ancillary maneuvers

Surgical approach to posterior urethroplasty following trauma is most commonly performed via a perineal incision, as seen in 95% of the patients analyzed here. The decision to proceed with an abdominoperineal approach is based on the factors limiting exposure, visibility or mobility of the posterior urethra, or on the presence of exceptionally long distraction defects.

Koraitim found that an abdominoperineal approach was best reserved for complex cases with defects greater than 2.5 cm and was required in 40/155 (26%) of pelvic fracture patients undergoing posterior urethroplasty [26]. Others have suggested that this approach is best reserved for patients with long urethral defects (> 3 cm), a history of abscess or fistula, or those with prior rectal or urethral surgeries [4, 27, 28]. As stated by Kizer et al., the additional exposure provided by this approach aids in mobilization of the proximal urethra and prostate, and better allows for a tension-free anastomosis to be performed [4]. This is especially important, as failure in these cases is often believed to be related to poor proximal urethral exposure and mobilization [28].

The utility of supracrural rerouting remains controversial within the literature. Seventy-three percent of patients in Koraitim's above referenced series were completed with urethral mobilization alone, with an additional 24% requiring supracrural rerouting during abdominoperineal repair [26]. Flynn et al., however, reported that of the 120 patients treated with perineal posterior urethroplasty, only 8% were completed with urethral mobilization alone [3]. In their experience, 34% of patients required corporal splitting, 12% inferior pubectomy, and 38% supracrural rerouting. These numbers vary dramatically from those reported by Kizer et al., who found that in 142 cases, 66% of patients were treated with urethral mobilization alone and that corporal rerouting was required in only 2.8% of patients [4]. This was further supported by a report of 82 patients by Morey in which supracrural rerouting was never required [6].

In the present study, we found that supracrural rerouting was rarely utilized. While this may be due to surgeon bias based on training, it has been our experience that routine use of high lithotomy positioning with adequate proximal and distal mobilization of the urethra to the level of the penoscrotal junction allows for sufficient mobility and enables us to obtain a tension-free anastomosis without more complex maneuvers in the majority of patients. In cases where this is insufficient, the addition of corporal splitting appears to provide the needed visualization and exposure for the majority (86%) of patients, with pubectomy only rarely required. While risks of supracrural rerouting are generally anecdotal and not well described in the literature, it appears that this procedure can often be avoided with alternative means of exposure and mobilization [4].

Success and secondary procedures

Despite the complexity of the procedure, reported long-term success rates in excess of 90% are common, and this is echoed in the current study [2, 4–6, 9, 26, 28]. While our data do not allow us to comment on the outcomes of interventions following posterior urethroplasty failure, prior studies have suggested that both minimally invasive and open surgical options may have a role [2, 4].

Limitations

There are a number of limitations inherent to this study. PFUI are rare and even at large referral centers, posterior urethroplasty following PFUI relatively uncommon. Similarly, the referral nature of the practices of participating surgeons in this study limits the availability of follow-up data for a number of patients. Particulars of surgical technique are not standardized among providers and some of these differences may not be accounted for in the analysis. Similarly, as previously stated, bias in training may have impacted utilization of different techniques among providers and injury patterns are often heterogeneous limiting generalizability. However, examining multi-institutional outcomes shows that despite this heterogeneity, surgical success rates are high and similar to prior single-institution series. Lastly, the number of patients who underwent angioembolization is low and evaluation of a larger cohort of embolized men may provide further insight into the impact on surgical outcomes.

Conclusions

Posterior urethroplasty following PFUI remains a difficult, but frequently successful operation. In our experience, a history of pelvic angioembolization and longer distraction defects increase the risk of failure. Although a high proportion of these cases can be performed utilizing simple urethral mobilization and scar excision, surgeons should be prepared to perform more advanced ancillary maneuvers or surgical approaches when required to ensure a tension-free mucosal anastomosis.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval :All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Animal welfare This article does not contain any studies with animals performed by any of the authors.

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