Population Analysis of Male Urethral Stricture Management and Urethroplasty Success in the United States

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OBJECTIVE To examine population-based practice patterns and outcomes related to urethroplasty for urethral stricture management.

METHODS We conducted a retrospective study of adult males with urethral stricture disease treated from January 2001 to June 2015 using the Clinformatics Data Mart Database. Treatment was defined as urethral dilation, direct visualized internal urethrotomy, and urethroplasty. We then examined anterior or posterior urethroplasty outcomes defining failure as any subsequent procedure specific to urethral stricture disease occurring >30 days after urethroplasty. We used multivariable and time-to-event analysis to examine factors associated with failure.

RESULTS We identified 75,666 patients treated for urethral stricture disease, with 420 and 367 undergoing anterior and posterior urethroplasty, respectively. Urethroplasty utilization doubled from 2005 to 2015. One- and 5-year failure rates for anterior and posterior urethroplasty were 25% and 18%, and 40% and 25%, respectively, with median times to failure of 5.1 and 4.1 months. Failures were salvaged primarily with direct visualized internal urethrotomy, with salvage urethroplasty in 19% and 12% of anterior and posterior repairs, respectively.

CONCLUSION Despite increasing population-based urethroplasty utilization over the past decade in our insured cohort, we found higher rates of salvage treatments than reported by high-volume and expert surgeon reports. Further efforts appear warranted to balance workforce expertise and quality of urethroplasty care to meet increasing urethral stricture population needs. UROLOGY 123: 258−264, 2019. © 2018 Elsevier Inc.

Urethral dilation and direct vision internal urethrotomy (DVIU) remain the most common treatments for male urethral stricture disease. Unfortunately, this trend continues despite poor success rates (35-70%) when performed for nonobliterative bulbar strictures less than 2 cm.[1-5] In contrast, current AUA guidelines recommend urethroplasty as the primary treatment option for nonbulbar urethral strictures, any stricture longer than 2 cm, or for recurrent strictures after prior endoscopic treatment.[6,7]

Reported success rates for urethroplasty at 5 years range from 80-95%.[8] These durable results are primarily from single center, high-volume centers, or combined data from multiple urethroplasty experts. It is unknown if success rates for urethroplasty performed in the community (ie, population-level) are as successful and durable. This is important to understand given our aging population and limited, regionalized fellowship-trained workforce expertise. Moreover, there is a lack of consensus regarding definitions of success and failure after urethroplasty. Understanding population-based failure management will add context to comparisons between individual studies, surgical approaches, and surgeon competency.[9,10]

Recent studies have shown increased utilization of urethroplasty among newly certified urologists as compared to endoscopic treatments.[11] This may be a result of increased exposure to urethral reconstruction during residency as well as fellowship training.[12,13] There are currently 17

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reconstructive urology fellowships that focus on urethroplasty, verified by the Society of Genitourinary Reconstructive Surgeons. To better elucidate community-based practice patterns and outcomes of urethroplasty, we conducted a retrospective claims based study of a large cohort of urethral stricture patients over a 15-year period. To our knowledge, this is the first study to use population-based data to report urethroplasty outcomes inclusive of community practice resulting in a comprehensive examination of urethral stricture management across the US.

MATERIALS AND METHODS

Data Source and Study Population

We used data from the Clinformatics Data Mart Database (OptumInsight, Eden Prairie, MN) to conduct this study. This database contains administrative claims from a large, national health insurer with approximately 12 to 14 million unique members per year across the United States. Unique identifiers are assigned to permit longitudinal patient follow-up.

Using these data, we performed a retrospective cohort study of adult males surgically treated by urethral dilation, DVIU, or urethroplasty between January 2001 and June 2015. Patients were eligible for inclusion based on medical claims for separate independent procedures containing current procedure terminology codes, specific to urethral stricture treatment (Supplementary Appendix 1). Patients with less than 30 days of enrollment or less than 18 years old at the time of initial procedure were excluded. From this cohort, we identified patients who received urethroplasty, and selected those patients who received anterior (53410) or posterior (53415) urethroplasty for additional analysis.

We identified baseline patient characteristics including age, race, income, education level, region, and Charlson comorbidity score. Patients were also tracked longitudinally following urethroplasty to identify failures. We defined failure as any subsequent urethral procedure (DVIU, urethral dilation or urethroplasty) that occurred more than 30 days after urethroplasty. Urethral procedures performed for urethroplasty failure were termed "salvage treatments." We recorded time intervals between urethroplasty and failure, as well as the type and number of salvage treatments throughout follow-up.

Statistical Analysis

We used a student *t*-test for continuous variables, chi-square for nominal categorical variables, and Mantel-Haenszel chi-square for ordinal categorical variables. We also used time-to-event analysis to generate Kaplan-Meier curves to characterize urethroplasty failures. This was performed independently for anterior and posterior strictures without comparison. "Salvage procedures" were reported using median time to failure. We divided salvage treatments into 2 groups, endoscopic (urethral dilation or DVIU) and urethroplasty, and reported rates for the initial salvage treatment only. We determined the total number of salvage treatments from each group at the end of the study period or loss to follow-up. We used adjusted rates for proportional hazard models to determine predictors of urethroplasty failure.

All statistical analyses were performed using SAS v9.3 (SAS Institute, Cary, NC). This study was deemed exempt by the University of Michigan institutional review board.

RESULTS

We identified 75,666 unique patients treated for urethral stricture disease between January 2001 and June 2015. A total of 1602 received urethroplasty as initial treatment or following prior endoscopic treatment. We excluded 815 patients from the study because they had < 30 days of enrollment and/or age < 18 years. Our final cohort consisted of 420 patients who underwent anterior urethroplasty and 367 patients who underwent posterior urethroplasty. As detailed in Table 1, the mean age of the entire cohort was 48 years, 71% White and 29% non-White, 83% noncollege graduates, and over 90% had minimal comorbidity. Patient characteristics were largely similar between the groups, however, individuals in the anterior urethroplasty group were more likely to have undergone prior endoscopic treatment (urethral dilation or DVIU) compared to posterior urethroplasty patients ($P < .001$).

At a median follow up of 22.7 months, failure was observed in 134 (32%) anterior urethroplasty cases with a median time to failure of 5.1 months (standard deviation (SD), 2.1 months). At a median follow-up of 23.9 months, failure was observed in 78 (21%) of posterior urethroplasties with a median time to failure of 4.1 months (SD, 1.8 months). We found the majority of failures in both groups, 72% and 77% respectively, occurred within the first year. As illustrated in Figure 1, the failure rate was inversely proportional to time from urethroplasty. Based on our Kaplan-Meier survival curves at 1-year, the failure rate approximated 25% for anterior urethroplasty and 18% for posterior urethroplasty. Corresponding failure rates at 5 years approximated 40% and 25%, respectively (Fig. 1A).

We found the majority of failures, 86% and 94% respectively, were managed with urethral dilation or DVIU as the first salvage treatment. Salvage urethroplasty was performed in the minority of patients with 37 (28%) of anterior urethroplasty failures and 14 (18%) of posterior urethroplasty failures (Table 2). Figure 1B demonstrates the increasing trend in urethroplasty utilization, particularly between 2005 and 2015, from 80 to 160 cases per year, and the failure rate of urethroplasty remained relatively stable, and in fact, decreased slightly between 2012 to 2015, despite increasing utilization.

As shown in Table 3, our multivariable analysis revealed no differences in outcomes related to patient, age, race, and income status for anterior urethroplasty patients. The likelihood of failure following anterior urethroplasty was lower among patients with lower Charlson comorbidity score, as well as among patients who underwent 1-2 prior endoscopic treatments (adjusted hazard ratio (aHR) 0.317 $P < .0001$), or 3 or more prior endoscopic treatments (aHR 0.396, $P = .0004$) (Table 3). Among patients treated with posterior urethroplasty, age < 40 years was associated with a decreased likelihood of failure (HR 0.407, $P = .0057$). We also found lower education attainment was associated increased risk of posterior urethroplasty failure (Table 3).

COMMENT

To our knowledge, this is one of the largest examinations of urethroplasty outcomes inclusive of community

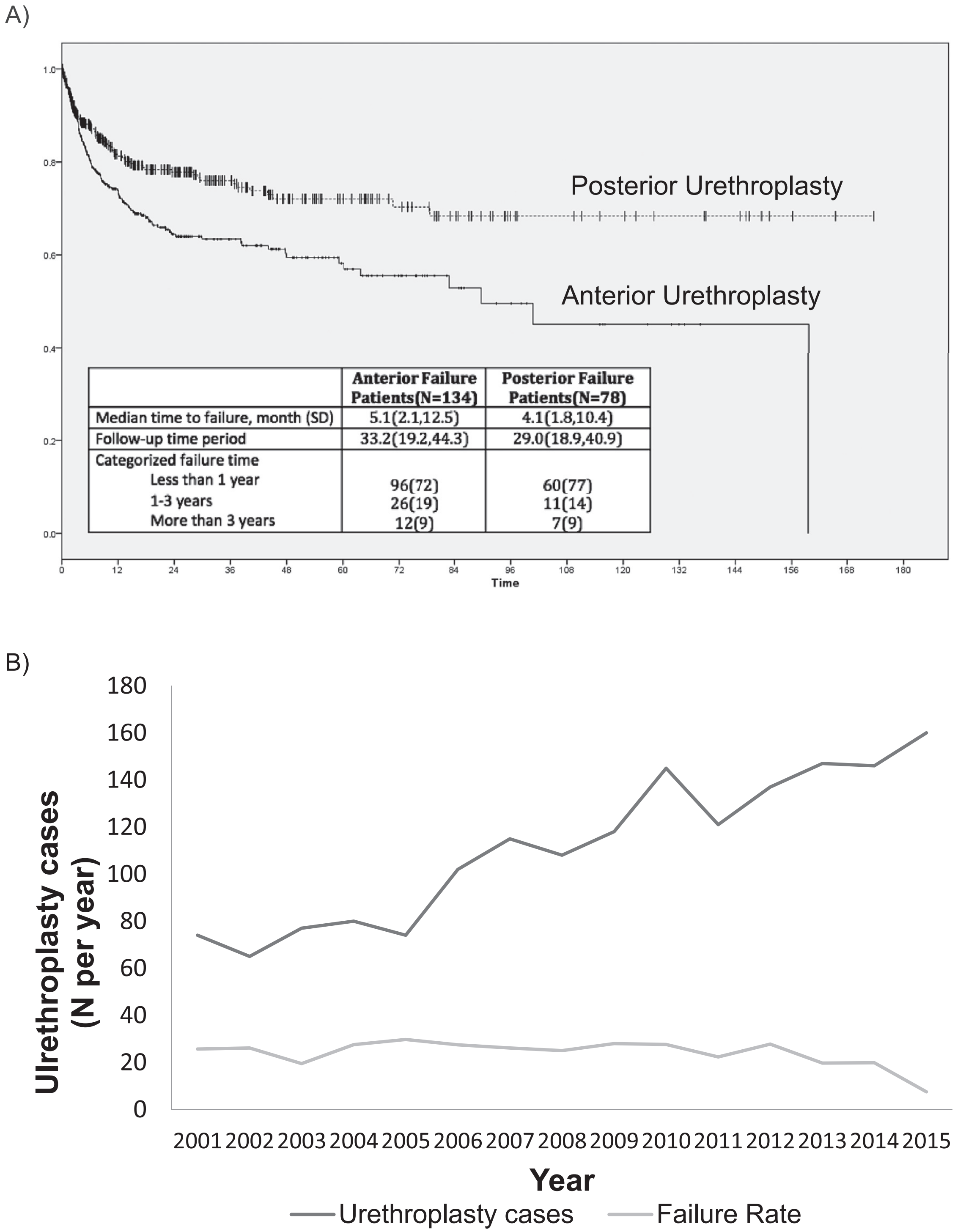
Table 1. Comparison of patient characteristics across anterior and posterior urethroplasty

Patient Characteristic	All (n = 1602)	Anterior Urethroplasty (n = 420)	Posterior Urethroplasty (n = 367)	*P* Value
Age (years), median (IQR)	48 (35-62)	51 (37-62)	46 (34-61)	0.109
Race/Ethnicity, N (%)				
White	1134 (71)	324 (77)	272 (74)	0.323
Non-White	468 (29)	96 (23)	95 (26)	
Education Level, N (%)				0.810
Less than 12 grade	12 (1)	3 (1)	3 (1)	
High school	447 (29)	112 (28)	91 (26)	
Less than Bachelor's	805 (53)	209 (51)	198 (56)	
Bachelor's or more	245 (16)	81 (20)	62 (17)	
Unknown	9 (1)	2 (1)	2 (1)	
Yearly Income, N (%)				
<$75K	546 (34)	130 (31)	128 (35)	
$75K-$99K	202 (13)	63 (15)	50 (14)	0.074
$100K+	431 (27)	139 (33)	94 (26)	
Unknown	423 (26)	88 (21)	95 (26)	
Region, N (%)				
East	524 (33)	133 (32)	106 (29)	
Central	789 (49)	212 (50)	181 (49)	0.475
Mountain	154 (10)	40 (10)	47 (13)	
Pacific	130 (8)	34 (8)	33 (9)	
Unknown	5 (0.3)	1 (0.2)	0 (0)	
Charlson co-morbidity index, N (%)				
0	1686 (92)	400 (95)	342 (93)	
≥1	137 (8)	20 (5)	25 (7)	0.217
Total follow-up (days), median (IQR)	931 (448,1837)	692 (271,1411)	727 (250,1475)	0.357
Prior endoscopic treatment, N (%)	—	351 (84)	201 (55)	<0.001
Suprapubic tube prior to urethroplasty, N (%)	—	63 (15)	65 (18)	0.304

providers providing a "real world" perspective for this complex surgery. We observed higher failure rates than previously published results from high volume centers and fellowship-trained surgeons. The timing of stricture recurrence and the success of salvage treatments were consistent with prior reports. While the failure rates are higher than prior reports, our results demonstrate that the majority of urethroplasties are successful; however, it is well understood that endoscopic management is not as successful or durable. Overall, further efforts appear warranted to balance workforce expertise and quality of urethroplasty care to meet increasing urethral stricture population needs.

Among our cohort, failure rates were significant at 32% for anterior urethroplasty and 21% for posterior urethroplasty, at mean follow up of < 3 years. A systematic review by Meeks et al. reported an overall recurrence rate of 15.6%, with failure rates between 13.9-18.4% following anterior repairs and 17.5% after posterior repair.[8] Additionally, Andrich et al reported after substitution anterior urethroplasty, a failure rate of 12% at 1 year and 21% at 5 years, and 7% and 12%, respectively, for anastomotic urethroplasty.[14] Whitson et al, from another high volume center, reported on 127 substitution urethroplasties, failures of 20% at 1 year and 33% at 5 years.[15] Moreover, Koraitim and Kamel found a 12% failure rate with a median of 5.5 year follow-up among patients who underwent posterior urethroplasty after pelvic fracture urethral injuries.[16] Our failure rates were markedly different than published reports, particularly with anterior urethroplasty where 25% vs 12% failed at 1 year, and 40% vs 23% failed at 5 years.[8,15,17] This begs the question, why our population-based urethroplasty outcomes are so much worse than the experts? And, should urethral reconstruction be best left in the hands of "expert" urologists? Perhaps they were more likely to take on posterior reconstruction resulting in better outcomes?

There are several possible explanations for the difference in outcomes.[17-19] Urethroplasty surgery has a significant learning curve that requires large surgical volumes for consistent successful outcomes, which may explain our 5-year poor outcomes.[19] Faris et al, noted of 613 cases by 6 expert surgeons, that 100 urethroplasty cases and 70 bulbar urethroplasty cases were needed to reach proficiency.[19] Fossati et al, analyzed 546 buccal graft urethroplasties, and concluded that surgical success of one-stage urethroplasty is highly influenced by surgeon experience and that failure rates became <20%, only after 400+ cases.[20] That said, recent case logs of certifying and recertifying urologists by the AUA, note that of urethral stricture management, only 3.9% is urethroplasty, and 0.9%, buccal graft.[11] Moreover, even with the highest performing



	Anterior Failure Patients(N=134)	Posterior Failure Patients(N=78)
Median time to failure, month (SD)	5.1(2.1,12.5)	4.1(1.8,10.4)
Follow-up time period	33.2(19.2,44.3)	29.0(18.9,40.9)
Categorized failure time		
Less than 1 year	96(72)	60(77)
1-3 years	26(19)	11(14)
More than 3 years	12(9)	7(9)

Figure 1. (**A**) Unadjusted salvage treatment-free survival after urethroplasty. (**B**) Trends in urethroplasty utilization and failure rates between 2001-2015.

(10th percentile) urologists, they only perform 10 urethroplasties yearly. Thus, most practicing urologists have little continuing experience and will never reach the learning curve thresholds.

Our data is confounded because the types of urethral reconstruction are not detailed. This is of particular concern in our anterior urethroplasty cohort, considering the significantly better outcomes for anastomotic over substitution urethroplasty. Our high failure rate could thus be explained if our urethroplasty cases were mostly substitution type. Additionally, current current procedure terminology coding does not distinguish penile from bulbar urethroplasty, which is a major limitation. One-stage penile urethroplasty requires substitution with a flap and/or graft and thus an inherently lower success rate compared especially to an anastomotic bulbar urethroplasty. In a systematic

Table 2. Salvage treatments characteristics

	Anterior Failure Patients (N = 134)	Posterior Failure Patients (N = 78)	*P* Value
Median time to failure, month (SD)	5.1 (2.1,12.5)	4.1 (1.8,10.4)	0.456
Number (%) with salvage DVIU or dilation	115 (86)	73 (94)	0.074
Number (%) with ≥ 1 salvage DVIU or dilation	47 (35)	29 (37)	0.758
Median (range) salvage DVIU or dilation	1 (1-2)	1 (1-2)	
Mean (SD) salvage DVIU or dilation	1.8 (1.4)	1.9 (1.9)	0.766
Number (%) with Salvage urethroplasty	37 (28)	14 (18)	0.107
Median (range) salvage urethroplasties	1 (1-1)	1 (1-1)	
Mean (SD) salvage urethroplasties	1.3 (0.7)	1.1 (0.4)	0.414

review, one-stage penile urethroplasty had an average 75.68% success at mean follow-up of 32.8 months.[18] Stricture etiology is also unknown, which may impact the complexity of reconstruction and thus failure rate. Furthermore, insurance coding doesn't accurately reflect stricture etiology and thus complexity of urethral-reconstruction, which may also impact surgical success, especially in cases involving history of hypospadias and lichen sclerosus. We chose repeat urethral procedures as the definition of failure, which is the most practical to use in a population analysis. Definitions vary widely and include patient reported outcome measures, uroflowmetry, luminal calibration by bougienage, or narrowing on cystourethroscopy or urethrography. There are even reports of salvage urethral dilation or DVIU after urethroplasty being considered a successful outcome.[10,21] These variations can wildly affect how outcomes are reported and confound comparisons. Thus for consistency, we used the same definition of failure as the bench mark studies for urethroplasty outcomes. Currently, there is no consensus definition of surgical success in the literature, and surely, if we chose more stringent criteria of success, then the success rates of urethroplasty in this cohort may have been even worse. Taking these limitations into consideration, our findings still demonstrate a nontrivial rate of additional procedures following urethroplasty in the community.

Consistent with prior publications on urethroplasty with long-term follow-up, we also observed a time-dependent pattern of recurrence and continued risk of failure.[15] Irrespective of technique, it is estimated that over 50% of recurrences occur within the first year of follow-up.[17-19] Similarly, our cohort had a median time to failure of 5.1 and 4.1 months for anterior and posterior urethroplasty, respectively. After anterior urethroplasty, we observed a consistent pattern of attrition over time, similar to expert series from London (Andrich), San Francisco (Whitson), and Hamburg (Fisch) at 5-10 years.[7,14,15,17] Our failures after posterior urethroplasty plateaued after 5 years of follow-up; similar to results for anastomotic urethroplasty.[7]

Interestingly, over 80% of our study patients who failed urethroplasty underwent a salvage urethrotomy. Previous studies have estimated success rates of 50-60% for urethrotomy for anterior urethroplasty failure.[21,22] Similarly, the majority of our patients only required one DVIU after failure. There were only 35 patients (17% of failures) that underwent subsequent urethroplasty after failure. Our results appear consistent with prior studies on management of stricture recurrence where most recurrences are short annular bands and thus amenable to urethrotomy.[21,22]

Table 3. Adjusted rate for proportional hazard model of clinical factors associated with failure of one stage anterior urethroplasty and posterior urethroplasty

	Anterior Urethroplasty Adjusted HR (95% CI)	*P* Value	Posterior Urethroplasty Adjusted HR (95% CI)	*P* Value
Age > 60	1		1	
Age < 40	0.968 (0.602-1.56)	0.894	0.407 (0.215-0.770)	0.006
White	1		1	
Non-White	1.173 (0.736-1.87)	0.502	0.699 (0.385-1.269)	0.239
Bachelor or more	—		1	
Less than 12 grade	—		12.853 (2.224-74.292)	0.004
High school	—		2.74 (1.089-6.894)	0.032
>$100K	1		1	
<$75K	0.85 (0.517-1.398)	0.522	1.216 (0.59-2.505)	0.596
Charlson comorbidity score ≥ 1	1		1	
Charlson comorbidity = 0	0.481 (0.231-0.999)	0.049	0.681 (0.305-1.522)	0.349
Initial treatment before urethroplasty	1		1	
1-2 Endoscopic treatment before urethroplasty	0.317 (0.21-0.479)	<0.0001	1.069 (0.613-1.866)	0.813
≥ 3 Endoscopic treatment before urethroplasty	0.396 (0.238-0.661)	<0.001	1.399 (0.676-2.895)	0.366
No SPT treatment before urethroplasty	1		1	
≥ 1 SPT treatment before urethroplasty	0.956 (0.53-1.734)	0.884	1.156 (0.594-2.249)	0.670

There are multiple factors that are known to affect urethroplasty outcomes and recurrence rates.[23,24] In contrast, Breyer et al, found that patient comorbidities did not impact urethroplasty outcomes.[17] We observed a decreased likelihood of failure following anterior urethroplasty in patients with fewer comorbidities and those having prior endoscopic treatments prior to urethroplasty. In patients who underwent posterior urethroplasty, there was an increased risk of failure amongst patients with lower education level and significantly improved outcomes in patients less than 40 years of age (compared to those over 60 years of age). Whereas, Chapman et al, found that age was not an independent predictor of urethroplasty success.[23] We found no prior study evaluating education status as it relates to outcomes of urethral stricture management. Our finding of increased failure among those with lower educational status may be representative of barriers to healthcare access and disparities of care, despite being insured, highlighting a potential avenue of investigation.

In contrast to our study findings, the preponderance of published evidence suggests that successive DVIU is predictive of subsequent anterior and posterior urethroplasty failure and more complex urethral reconstruction.[24] However, a recent report of 596 bulbar urethroplasties, at a mean follow-up of 5.4 years, found that prior DVIU did not negatively impact urethroplasty success.[23] The significance of prior endoscopic procedure as a positive predictor of urethroplasty success in our cohort is unclear. Our findings might be explained by selection bias, in that the strictures in our patients were less severe and thus more amenable to trial of endoscopic treatment. Those with severe strictures may not have been candidates for an initial trial of endoscopic treatment, and thus at higher risk for urethroplasty failure.

In our population-based insured cohort, we found an increasing utilization of urethroplasty, particularly within the last decade.[11] It is important to note that among the 75,666 patients with a diagnosis of urethral stricture, only 1602 underwent urethroplasty and that even despite the increasing utilization of urethroplasty there is still a large majority of these patients being managed endoscopically. The observed upward trend in urethroplasty in our cohort is similar to prior reports of urethroplasty numbers per year from urologist recertification surgical logs, the Veteran Affairs (VA) database, and the Nationwide Inpatient Sample.[1,25,26] The VA report is limited because of its older cohort (eg, mean age 59.9 years) compared this population[26] Our cohort is very generalizable to the overall US population; the racial distributions and education levels of our cohort closely mirrors the distribution in the 2010 US census.[27]

In addition to the limitations already discussed, the lack of granularity and information regarding stricture characteristics, surgical technique, and surgeon experience and/or hospital setting may limit inference. The impact of stricture location, etiology, and length, urethroplasty technique (substitution, anastomotic, combined), as well as surgeon experience on surgical success has been well described, and is necessary to fully contextualize our results.[17,20] However, the majority of our findings provide useful information on current practice and failure patterns in the community. Additionally, the dataset is limited by the lack of information regarding surgeon volume and experience with urethral reconstruction, and inexperience may explain to the findings of low utilization of urethroplasty relative to DVIU in this series. Similar to other population based studies that rely on diagnosis and procedure codes, the analysis is limited by coding errors which may have impacted our findings. Furthermore, patient data and long-term follow-up in this study are dependent on maintaining enrollment in a certain type of insurance. As changes in insurance carriers in the United States have become more common, patient censorship and gaps in enrollment may be associated with significant events that would not be captured. This would only serve to increase our failure rates over time.

CONCLUSION

To our knowledge, this is one of the largest examinations of urethroplasty in a "real world" population-based setting. We observed higher failure rates than previously published results from high volume centers. Timing of stricture recurrence and success of salvage treatment were consistent with prior reports. Overall, further efforts appear warranted to balance workforce expertise and quality of urethroplasty care to meet increasing urethral stricture population needs.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.urology.2018.06.059.

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