The Ideal Use of Catheters in Hypospadias Repair: An Experimental Study

Haci Polat[1]* Umut Gulacti[2]

Purpose: To find answers to some catheter-related questions in hypospadias repair such as which type of catheter should be used, with which catheter balloon inflation volume, and when should the catheter be removed from the urethra? As catheter use and post-op retention time varies among surgeons in hypospadias repair.

Material and methods: Fifty-four 10 French all-silicone- and 54 latex Foley catheters were prepared and assigned to groups as senary. The catheter's balloons were inflated with 2, 3 and 5 mL of sterile water. The catheters were submerged in artificial human urine and then removed from the solution at 24, 72, and 168 h after submersion. The catheter balloon volume losses, increases in the transverse diameter of the catheters, and angulation of the catheter tips were measured to determine catheter degradation.

Results: The minimum balloon volume loss was 0.4 mL in the group of all-silicone catheters that were inflated with 2mL and deflated after 24h (2mL 24h). According to balloon volume and deflation time, there were no increases in transverse diameter of the four groups of all-silicone catheters; 2mL 24h, 3mL 24h, 5mL 24h, and 2mL 72h. With 1 mm expansion, the lowest increase on transverse diameter of the latex catheters occurred in five groups; 2mL 24h, 3mL 24h, 5mL 24h, 2mL 72h, and 2mL 168h.

Conclusion: An all-silicone catheter inflated with 2mL and removed from the urethra within 24-72 hours may be the ideal catheter use in hypospadias repair.

Keywords: Children; hypospadias; urinary catheters

INTRODUCTION

In hypospadias repair, the type of catheter used and post-op retention time varies among surgeons. Generally, all-silicone Foley catheters are used during hypospadias repair and they are retained in the urethra between 0 to 7 days. Several problems associated with catheters such as infection, encrustation, bladder spasm, catheter blockage, and trauma related to catheter insertion may occur in hypospadias repair [(1)]. However, there are very few data about mechanical problems with catheter retention time, catheter removal, and use. Additionally, most of the existing studies relate to suprapubic catheters and were associated with 4-6 week long-term catheters [(2, 3)]. There are few studies on pediatric-sized catheters in the literature. One of the most influential reports is the study of Hardwick et al. on hypospadias model [(4)]. However, there were some important shortcomings of that study such as the sole inclusion of all-silicone catheters and that these were only examined after seven days of degradation, with no additional time points. We were inspired by this study and set out to investigate the degradation of latex (rubber) Foley catheters and all-silicone catheters with different balloon inflation volumes and different deflation periods in this study. In our current practice of hypospadias repair, we use latex Foley catheters with 2 mL balloon inflation volume and 24-48 hours urethral retention[(5)]. We tried to find answers to some catheter-related questions in hypospadias repair such as which type of catheter should be used, with which catheter balloon inflation volume, and when should the catheter be removed from the urethra?

MATERIALS AND METHODS

Fifty-four 10 French all-silicone- and 54 latex Foley catheters (Rüsch, Laboratoires Pharmaceutiques, Betschdorf, France) were prepared. All catheters were numbered. All-silicone catheters were assigned to 9 groups as senary. Groups were formed as follows; catheter balloons were inflated with 2, 3 and 5 mL of sterile water. Latex catheters were grouped in the same way. The maximum transverse and longitudinal dimensions of the catheter balloon were measured with Vernier calipers and catheters were inflated. Urea (17.1 g) was added to a 1L compound sodium lactate solution to simulate human urine. All catheters were submerged in this solution and incubated in the dark at 37°C. Catheters were removed from the solution at the specified times (24, 72, and 168h) after submersion. The catheter balloons were inspected for failure, deflation, and measured with Vernier calipers (maximum longitudinal and transverse dimensions). Balloon aspiration volume was recorded. All catheters were digitally photographed using a Canon EOS 650D camera on a standardized scaled background. The photographs were analyzed using ImageJ software (ImageJ1.40v; http://rsb.info.nih.gov/ij/). Angulation of the catheter tip and maximum transverse external axis of the catheters was recorded.

[1]Adıyaman University Medical Faculty, Department of Urology, Adiyaman, Turkey.
[2]Adıyaman University Medical Faculty, Department of Emergency, Adiyaman, Turkey.
*Correspondence: Adiyaman University, Faculty of Medicine, Department of Urology, Adiyaman, Turkey.
Tel: +90 416 216 10 15-3317. E-mail: dr.polat@hotmail.com.
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Table1. The comparisons in terms of catheter balloon inflation volume losses, changes in the transverse diameter of the catheters, and angulation of the catheter tips in both catheter type.

	Latex				Silicon			
	24 h	**72 h**	**168 h**	***p*-value** [d]	**24 h**	**72 h**	**168 h**	***p*-value** [d]
Inflation volume losses (ml)								
2 ml	0.75 (0.23)	0.80 (0.20)	0.60 (0.13)	0.052	0.40 (0.05)[b,c]	0.50 (0.10)[b]	0.60 (0.10)[c]	< 0.001
3 ml	0.85 (0.13)	0.85 (0.13)	0.75 (0.25)	0.391	0.60 (0.03)[c]	0.65 (0.10)[a]	0.80 (0.10)[a,c]	< 0.001
5 ml	1.00 (0.25)	0.80 (0.13)	0.80 (0.00)	0.042	0.70 (0.10)[c]	0.80 (0.03)[a]	1.05 (0.20)[a,c]	< 0.001
Inflation volume losses (%)								
2 ml	37.5 (11.25)	40.0 (10.00)	30.0 (6.25)	0.052	20.0 (2.50)[b,c]	25 (5.00)[b]	30 (5.00)[c]	< 0.001
3 ml	28.3 (4.17)	28.3 (4.17)	25.0 (8.33)	0.391	20.0 (0.83)[c]	21.7 (3.33)[a]	26.7 (3.33)[a,c]	< 0.001
5 ml	20.0 (5.00)	16.0 (2.50)	16.0 (0.00)	0.042	14.0 (2.00)[c]	16.0 (0.50)[a]	21.0 (4.00)[a,c]	< 0.001
Transverse diameter increase (mm)								
2 ml	1.0 (1.00)	1.0 (0.50)	1.0 (0.50)	0.904	0.0 (0.25)[c]	0.0 (0.25)[a]	1.0 (0.00)[a,c]	0.005
3 ml	1.0 (0.25)	1.5 (0.50)	2.0 (0.25)	0.032	0.0 (0.25)[c]	1.0 (0.25)	1.2 (0.13)[c]	0.007
5 ml	1.0 (1.00)	2.0 (0.50)	2.0 (0.00)	0.031	0.0 (1.00)[b,c]	1.7 (0.63)[b]	2.0 (0.63)[c]	0.004
Angulation of the catheter tips (°)								
2 ml	7.8 (4.33)	2.6 (11.05)	7.5 (7.29)	0.484	0.8 (2.22)	1.0 (0.49)	1.0 (0.43)	0.802
3 ml	3.1 (2.11)	4.7 (6.76)	5.6 (7.39)	0.484	1.3 (1.40)	1.1 (1.15)	1.0 (0.50)	0.751
5 ml	2.9 (1.04)	8.1 (8.49)	5.5 (6.24)	0.139	1.7 (0.56)	1.5 (0.64)	1.4 (0.19)	0.342

a: 72 h vs 168 h ($p < 0.0028$), b: 24 h vs 72 h ($p < 0.0028$), c: 24 h vs 168 h ($p < 0.0028$). d: The comparisons among durations of discharge, Kruskal Wallis test, according to the Bonferroni correction $p < 0.0083$ was considered as statistically significant

Statistical Analysis

Data analysis was performed using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, IL, United States). Kolmogorov-Smirnov test was used to determine whether the continuous variables were normally distributed. The Levene test was used for the evaluation of homogeneity of variances. Data were shown as median (IQR). The Kruskal-Wallis test was used for comparisons between more than two independent groups. When the P-value from the Kruskal-Wallis test was statistically significant, the Bonferroni-adjusted Mann-Whitney U test was used to identify which group differed from the others. A *P*-value less than 0.05 was considered statistically significant. Bonferroni correction was used to check

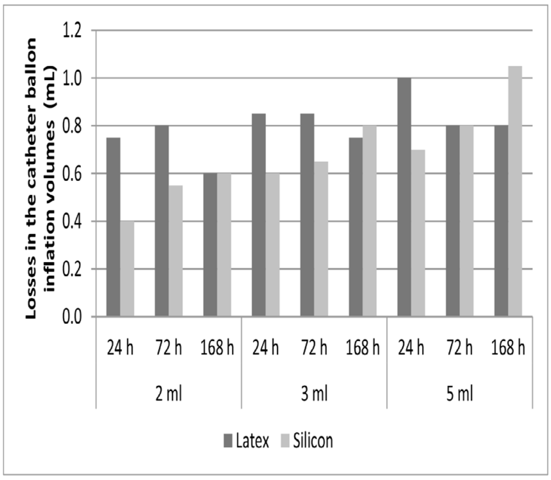

Figure1. Losses occurred in the balloon volumes at different deflation times. Losses in the balloon volume of silicone catheters increased statistically significantly ($p < 0.001$) in all inflation volumes in parallel with deflation times.

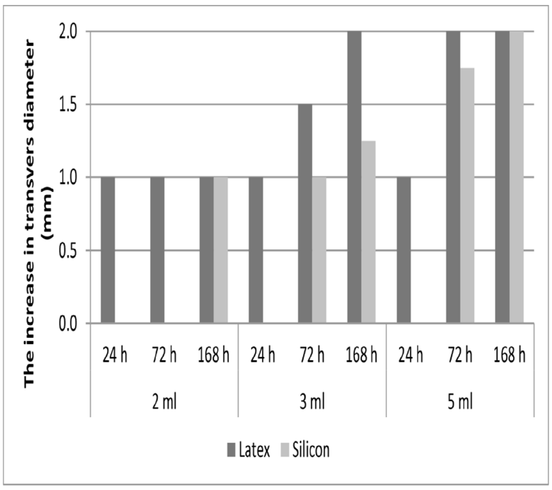

Figure2. The increase in transverse diameter of catheters at different inflation volumes and deflation times.

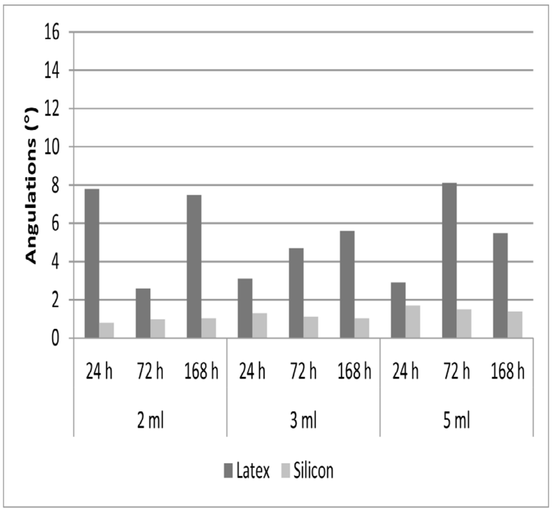

Figure3. Angulations at the tip of catheters. There was a non-statistically significant angulation between 2.9 and 8.1 degrees in the latex catheters (p > 0.05).

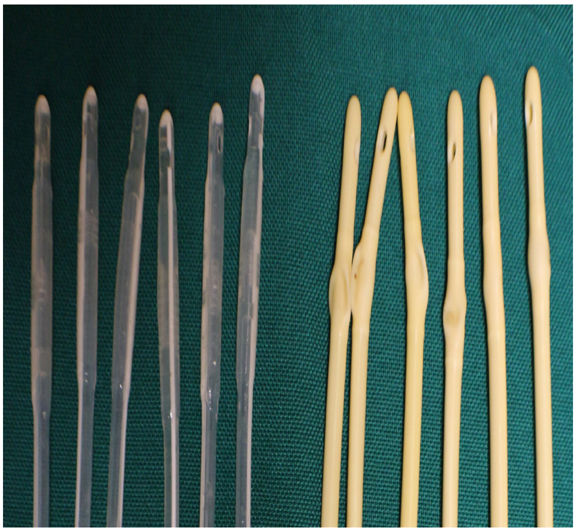

Figure 4. The images of the some catheters which were inflated with 2 mL and were deflated after 72 hours (2mL 72 h). "Cuffing effect" seems to be evident in latex catheters.

for Type I errors in all possible multiple comparisons.

RESULTS

The catheter balloon volume losses, transverse diameter increases, and catheter tip angulations of the different balloon inflation volumes at different deflation times are shown in **Table 1**. Statistically significant volume losses occurred in parallel to increasing deflation times in all three balloon-inflation volumes of all-silicone catheters ($P < .001$). The lowest volume loss was 0.4 mL in the 2mL inflated all-silicone catheter group with deflation after 24h (2 mL 24 h). Also greatest volume loss was 1.05 mL, which occurred in the 5mL-inflated all-silicone catheters with deflation after 168 h (5mL 168h). Balloon volume loss was present in all latex catheter groups ranging between 0.6-1 mL. However, there was no statistically significant correlation between volume loss, catheter balloon inflation volumes, and deflation times ($P > 0.05$) (**Figure 1**). There was a statistically significant increase in the transverse diameter of the catheter balloon in each all-silicone catheter group of the three inflation volumes, in parallel to the increased balloon deflation time ($P < .005$). There was no change in the transverse diameter of the four groups of all-silicone catheters that were deflated after 24h (2mL 24h, 3mL 24h, and 5mL 24h) and those inflated with 2mL and deflated after 72h (2mL 72h). The largest increase of 2 mm occurred in 5mL-inflated all-silicone catheters that were deflated after 168h (5mL 168h) ($P < .005$). In latex catheters, the transverse diameter of the catheter balloon increased from 1 to 2 mm in all inflation volumes and deflation times, but there were no statistically significant correlation between inflation volumes and deflation times. With 1mm expansion, the smallest increase in transverse diameter of the latex catheters occurred in five groups; 2mL 24h, 3mL 24h, 5mL 24h, 2mL 72h, and 2mL 168h. The largest increase in transverse diameter of latex catheters occurred in the following catheters; 3mL 168h and 5mL 168h (**Figure 2**). There was a non-statistically significant minimal angulation between 0.8 and 1.7 degrees at the tip of the all-silicone catheters after balloon deflation ($P > .05$). Similarly there was a non-statistically significant angulation between 2.9 and 8.1 degrees at the tip of the latex catheters ($P > .05$). However, these angulations were also present in the catheters before catheter balloon inflation (**Figure 3 and Figure 4**).

DISCUSSION

To be relevant for clinical practice, we worked with 2, 3, and 5 mL catheter balloon inflation volumes and 24, 72, and 168 h deflation times. We think that inflation of catheter balloons with 1 mL would not be adequate in clinical practice to prevent catheters from spontaneously falling through the urethra; therefore, we worked with 2 mL catheter balloon inflation as the lowest volume. We routinely inflate catheter balloons with 2 mL in hypospadias repair practice [(5)] and to date we have not encountered any spontaneously falling catheters. The balloon mechanisms of catheters are 1-2 mm wider than the actual catheter gauge prior to inflation [(4)]. After deflation, the catheter balloon "cuffing" effect has been shown to increase the transverse diameter between 1 and 5 mm, and creases and ridges are formed [(6-8)]. This "cuffing" effect causes problems during catheter removal. As we predicted before the study, cuffing increased in both catheter groups when the balloon inflation volume increased and deflation time was extended. However, although this degradation increased in parallel to the catheter balloon inflation volume and deflation time in all-silicon catheters, this increases was variable in latex catheters. Several studies have reported the occurrence of cuffing is lower in latex catheters than in all-silicone catheters [(2, 3)]. However, our experimental results show that this perception may not be correct, at least in low balloon inflation volumes and with short deflation times. Although measurable cuffing did not occur at lower catheter balloon inflation volumes and short deflation times (2mL 24h, 3mL 24h, 5mL 24h, and 2mL 72h) in all-silicon catheters, it did occur in all groups of latex catheters.

CONCLUSIONS

We investigated the ideal use of catheters in pediatric hypospadias repair. In hypospadias repair, retention time of urethral catheters varies between physicians for various reasons from 0 to 7 days. When we considered our clinical practice together with these experimental results, we suggest that if a catheter is to be used, all-silicone catheters should be used, and that inflation with 2 mL and removal from urethra within 24-72 hours is the ideal form of catheter use. As a result of this study, we plan to change our practice and use all-silicone catheters in hypospadias repair.

CONFLICT OF INTEREST

There is no conflict of interest.

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REFERENCES

1. Ramakrishnan K, Mold JW. Urinary catheters: a review. Int J Fam Pract 2005:2.
2. Parkin J, Scanlan J, Woolley M et al. Urinary catheter‘deflation cuff’ formation: clinical audit and quantitative in vitro analysis. BJU Int 2002; 90:666-71.
3. Jannings W, Kelly M. Difficulty in removing suprapubic urinary catheters in home based patients: a comparative descriptive study. Aust J Adv Nurs 2001;19:20-5.
4. Hardwicke J, Jones E, Wilson-Jones N. Optimization of silicone urinary catheters for hypospadias repair. Journal of Pediatric Urology 2010;6:385-8.
5. Polat H, Yucel MO, Cift A et al. The use of latex foley catheter in repair of hypospadias the most common seen congenital penile anomaly. Int J Clin Exp Med 2015;8:13421-3.
6. Robinson J. Clinical skills: how to remove and change a suprapubic catheter. Br J Nurs 2005;14:30-5.
7. Robinson J. Deflation of a Foley catheter balloon. Nurs Stand 2003;17:33-8.
8. Robinson J. Suprapubic catheter removal: the cuffing effect of deflated catheter balloons. Br J Community Nurs 2003;8:205-8.