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Effect of Polyurethane and Silicone Stents on Rat Bladder Urothelium

Khalid Jamil, Nasir Chugtai, Muhammad Usman Khan
Department of Urology, Shaikh Zayed Medical Complex, Lahore

SUMMARY

A study was carried out to see effect of two commonly used ureteral stents, polyurethans and silicone on rat bladder mucosa. Experiments were done on 24 rats. They were divided into three groups. Silicon, polyurethane and control. Each comprised of eight rats. Study showed mean bladder weight was 0.085±0.014 gram in control group, 0.172±0.086 (p=0.004). in polyurethane and 0.111±0.014 in silicone group (p=0.02). Mean epithelial hyperplasia was 1.250±0.463 in control group, 4.750±2.053 (p=0.002) in polyurethane group and 2.875±1.126 in silicone group (p=0.004). Congestion of bladder mucosa and inflammatory cell infiltrate was more in polyurethane group but was not statistically significant. Encrustation was more on silicone and was not statistically significant. Clinically polyurethane stent are better than silicone due to low co-efficient of friction and excellent flow rate due to large lumen for drainage.

INTRODUCTION

Silicone and polyurethane are the polymers currently used for indwelling ureteral stents. Silicone is the gold standard for human tissue compatibility and is the primary choice for urinary tract.[1]

Drake et all were the first to investigate the effects of various plastic stents in experimental ureteric surgery in mongrel dogs. Pathological effects depended on the type of stent used and mainly consisted of an inflammatory infiltration of the ureteric wall with subepithelial fibroplasia and smooth muscle hypertrophy. Urothelial ulceration was also noted. Blum et al[2] tested encrustation upon three materials (silicone rubber, latex and polytetraflouorethylene). 3x4 mm pieces of materials were placed in the bladders of rats. Encrustation upon silicone rubber occurred in one third of the rats with infected urine and none at all in those with sterile urine. The commonly used method for biomedical testing of urinary catheters are, rat peritoneal implantation test,[3] rabbit muscle implantation[4] and cell culture test for inhibition of DNA synthesis.[5] These tests do not generally involve direct contact of the urinary tract epithelium with the catheter material. Their was a need to test for the reaction of bladder mucosa to direct contact with the bladder mucosa. We studied theses effects on rat bladder mucosa, which were found to be most suitable for microscopic evaluation.

MATERIAL AND METHODS

This study was done in the animal experimental laboratory, Punjab Postgraduate Medical Institute, Lahore.

Animal experimental study

It was not possible to study the histopathological changes and tissue reactions to these stents on the ureteral and bladder mucosa in human beings. To study these changes in uroepithelium an animal model was prepared.

White albino rats weighing between 150-200 grams were brought from mice colony, Veterinary Research Institute, Lahore and were kept in the animal house of the Punjab Postgraduate Medical Institute. During the experimental period they were given chicken chow diet and they had free access to tap water.

Experiments were done on a total of 24 rats.

The rats were divided into three groups and designated as "Silicone", "Polyurethane" and "Control". Each group comprised of 8 rats. The control group underwent a sham's operation while the experimental groups received anaesthesia with a special funnel packed with cotton soaked in ether. After shaving the abdominal wall, the animals were placed on their back fixing them with sticking plaster. An incision 2 cm long was made in the anterior abdominal wall, the muscles were cut in the line of the incision. The bladder was opened and a 2 mm long 6Fr. size piece of stent was placed in the bladder. The bladder was then closed with 4/0 chromic catgut. The bladder mucosa was not stitched to avoid the reaction of the catgut, which might alter the reaction of the stent. The wound was closed in 2 layers with 3/0 chromic catgut. After the operation the animals were returned to their cages with free access to water and food. After 3 weeks under ether anaesthesia the bladder was opened, the stent removed and the degree of encrustation noted. The stent was preserved in 2 ml trypticase soya broth for culture. Cystectomy was done and the specimen fixed in bouine fixative. It was submitted to the histopathology department of Shaikh Zayed Hospital, Lahore, for gross and microscopic examination. Specimens were weighed on digital electronic, mettler PC440 balance, this instrument can record weight from 0.001 grams to 250 grams. Each specimen was sectioned with a surgical knife into representative sections and the tissue passed totally. These sections were labelled and processed in a tissue processor (2LF-Shandon computerized automated tissue processor). Blocks were made in molten wax. These blocks were frozen and three micron thick sections were made by the Leitz microtome (rotary type 1512) which were then spread in a warm water bath (Thermostirras 85 gallon Kampat 58°c). These sections were taken up on microscopy glass slide which were previously albuminised and subsequently stained with standardized haemotoxylin and eosin stain. These slides were examined under a microscope in x 10 x 20 and x 40 power objectives (Leitz).

Statistical Analysis

Nominal variables were analysed by Chi Square test and numerical variable was analysed using student 't' test. For simultaneous comparisons of all three groups Kruskil Wallis one way ANOVA was used. Two group comparison between silicone and polyurethane groups were done with Mann Whitney U test.

The following parameters were noted and graded.

1. **Urinary bladder weight in grams.**

2. **Epithelial hyperplasia** (cell wall thickness).

grade 0 (3 to 4 cell thick)	Nil
grade I (4 to 6 cell thick).	Mild
grade II (7 to 9 cell thick).	Moderate
grade III (more than 9 cell thick)	Severe

3. **Papillary infolding**

Nil	grade 0
Mild	grade I
Moderate	grade II
Severe	grade III

4. **Congestion of Bladder Mucosa**

Nil	grade 0
Mild	grade I
Moderate	grade II
Severe	grade III

5. **Inflammatory Cell Infiltrate**

1 to 2 cells/HPF	grade 0
2 to 10 cells/HPF	grade I
11 to 15 cells/HPF	grade II
Numerous cells/HPF	grade III

6. **Stent Encrustation**

Nil	grade 0
Mild	grade I
Moderate	grade II
Severe	grade III

RESULTS

The main parameters of study such as urinary bladder weight, transitional epithelial hyperplasia (cell layer thickness), papillary infolding, congestion of bladder mucosa, inflammatory cell infiltrate (in the lamina propria), stent encrustation were analyzed and compared with the control group. Also a comparison between the silicone group and the polyurethane group was made.

Mean value of three groups are given in Table 1. Table 2 shows significant difference in mean bladder weight and mean epithelial hyperplasia in polyurethane and silicon group than compared with control (Fig.1). Table 3 shows comparison of inflammatory cell infiltrate and stent encrustation scores between polyurethane and silicone group. We did not find any significant difference between polyurethane and silicone group in term of papillary infolding, inflammatory cell infiltrate and stent encrustation.

Table 1: Comparison of variables in three groups (n=8)

Variables	Control	Polyurethane	Silicone
Urinary bladder weight in grams±SD	0.070-0.118 ±0.014	0.099-0.371 ±0.086	0.094-0.0135 ±0.014
Epithelial hyperplasia			
Nil	6 (75)	Nil	Nil
Grade I	2 (75)	2 (25)	4 (50)
Grade II	Nil	1 (12.5)	4 (50)
Grade III	Nil	5 (62.5)	Nil
Papillary infolding			
Nil	8 (100)	Nil	Nil
Mild	Nil	4 (50)	7 (87.5)
Moderate	Nil	2 (25)	1 (12.5)
Severe	Nil	2 (25)	Nil
Congestion of bladder mucosa			
Nil	8 (100)	Nil	Nil
Mild	Nil	8 (100)	8 (100)
Moderate	Nil	Nil	Nil
Severe	Nil	Nil	Nil
Inflammatory cell infiltrate			
Nil	8 (100)	Nil	Nil
Grade I	Nil	3 (37.5)	4 (50)
Grade II	Nil	1 (12.5)	2 (25)
Grade III	Nil	4 (50)	2 (25)
Stent encrustation			
Nil		5 (62.5)	4 (50)
Mild		1 (12.5)	1 (12.5)
Moderate		2 (25)	2 (25)
Severe		Nil	1 (12.5)

DISCUSSION

The urinary system presents an unstable chemical environment with super saturation of uromuciods and crystalloids at the inferface between the material and urine. This creates a significant problem for long term biocompatibility and bio

Table 2: Comparison of mean values of bladder weight and epithelial hyperplasia scores between control, polyurethane and silicone groups.

Variable	Control[a]	Polyurethane[b]	Silicone[c]
Bladder weight gms (Mean±SD)	0.0885±0.014	0.172±0.086	0.11±0.014
Epithelial hyperplasia score (Mean±SD)	1.25±0.463	4.75±2.053	2.87±1.126

* p values for bladder weight
a vs b 0.004
a vs c 0.02
b vs c > 0.05
*p values for Epithelial hyperplasia score
a vs b 0.002
a vs c 0.002
b vs c 0.004
Based on Kruskil Wallis One Way ANOVA

Table 3: Comparison of inflammatory cell infilatrate and Stent encrustation scores between Polyurethane and Silicone groups.

Variable	Polyurethane	Silicone	* p value
Papillary infolding score (Mean±SD)	2.75±0.08	2.12±0.354	>0.05
Inflammatory cell infiltrate score (Mean±SD)	4.0±1.19	3.38±1.30	>0.05
Stent encrustation score (Mean±SD)	1.62±0.91	2.00±1.19	>0.05

*Based on Mann Whitney U Test
Probability value (p value) of 0.05 and below was taken as the statistically significant.

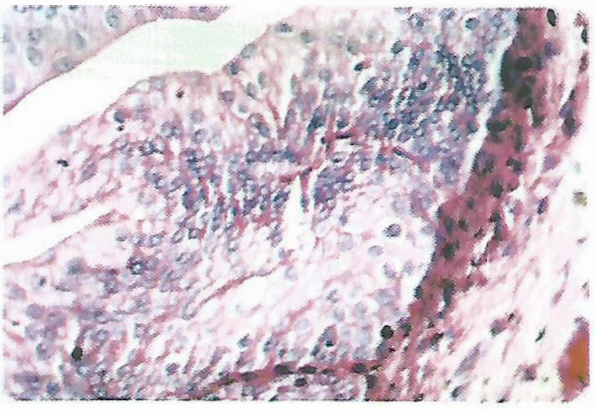

Fig. 1: Photomicrofilm of rats urinary bladder (polyurethane group). Section showing normal epithelium and lamina propria (Haemmatoxyline and Eosin x 400).

durability of devices within this system. Stent composition will determine the degree of reactivity.[6] The less reactive the polymer, the longer the time it can be left indwelling comfortably. This was proved. Our study shows that polyurethane a new material which is stiffer than silicone and low co-efficient of friction had higher epithelial hyperplasia and was statistically significant. Papillary infolding and inflammation, these pathological findings had an effect on patient symptomatology. Our findings are consisted with Marx et at, 1988. Silicone which is gold standard for tissue compatibility, but due to high co-efficient of friction more resistance the stent will offer to a guide wire.[7] So it is necessary to create thicker walled tube with small lumen to prevents kinks or collapse if silicone used.[8] In our study silicone has more encrustion than polyurethane.

Encrustation begins with the adherence of inflammatory products and leads to mineralization, infection and colonization does accelerate encrustation stone growth and potential stent obstruction. Encrustation of stent occurs principally in stone forming patients and degree of encrustation increases with time Microscopic encrustation has been demonstrated on all stents even without concomitant infection. Holmes et al[9] reported that the formation of encrustation in sterile urine may be dependent on both the urinary constituent and the property of the synthetic material Silicone polymer are more prone to encrustation Bacterial infection specially by urea splitting organism (Proteus), should be treated aggressively in stenting patients.[10]

CONCLUSION

The new sof-flax (polyurethane) stents are better for clinically use as compare to silicone as it is very stable. Thin outer wall permits the creation of tubes with significant large lumen, which permit an excellent flow rate and drainage over a longer period of time. We recommend polyurethan stents for clinical use due to low encrustation and better flow rate.

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REFERENCES

1. Drake WM Jr, Carroll J, Bartone F, Cottones RN, Kazal HG, Sumerai S, et al. Evaluation of materials used as ureteral splints. Surg Gynecol Obstet 1962; 114: 47-51.
2. Blum J, Skemp C, Reiser M. Silocone rubber ureteral prosthasis. J Urol 1963; 90: 276-80.
3. Talija M. Rat peritoneal implantation test. A new method of tinuetoxicity testing of urinary catheters. Br J Urol 1985a; 57: 329-33.
4. Jalja M, Andersson LG, Rutu M, Alfthan O. Toxicity testing of urinary cathers. Br J Urol 1985; 57: 579-84.
5. Ruutu M, Alfthan O, Talja M and Andersson LC. Cytotoxicity of latex urinary catheters. Br J Urol 1985; 57: 82-87.
6. Marx M, Bettman MA, Bridge S, Brodsky G, Boxt LM, Richie JP. The effects of various indwelling ureteral catheter materials on the normal canine ureter. J Urol 1988; 139: 180-84.
7. Hofmann, Rad Hartung R. Ureteral stents material adn new form. Urology 1989; 7: 154-57.
8. Mardis HK, Kroeger RM. Ureteral stents Urol Clin North Am 1988; 15: 471-78.
9. Holmes SAV, Miller PD, Crocker PR and Kirby RS. Encrustation of intraprostatic stents a comparative study. Br J Urol 1992; 69: 383-87.
10. Rose GA and Rosenbaum TP. Recurrent infectious stones with apparently negative cultures, the case for blind antibacterial treatment. Br J Urol 1992; 69: 234-39.

The Authors:

Khalid Jamil,
Medical Officer
Department of Urology,
Shaikh Zayed Postgraduate Medical Institute,
Lahore

Shamim Hashim
Assistant Prof.
Department of Urology,
Shaikh Zayed Postgraduate Medical Institute,
Lahore

Nasir Chughtai
Medical Officer
Department of Histopathology,
Shaikh Zayed Postgraduate Medical Institute,
Lahore

M. Usman Khan
Associate Professor
Department of Urology,
Shaikh Zayed Postgraduate Medical Institute,
Lahore

Address for Correspondence:

Khalid Jamil,
Medical Officer
Department of Urology,
Shaikh Zayed Postgraduate Medical Institute,
Lahore