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Original Article

Surgery Section

Differences in Bacterial Colonization and Biofilm Formation Property of Uropathogens between the Two most Commonly used Indwelling Urinary Catheters

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Introduction: Catheter Associated Urinary Tract Infections (CAUTI) are one of the most common cause of nosocomial infections. Many bacterial species show biofilm production, which provides survival benefit to them by providing protection from environmental stresses and causing decreased susceptibility to antimicrobial agents. Two most common types of catheters used in our setup are pure silicone catheter and silicone coated latex catheter. The advantage of pure silicone catheter for long term catheterization is well established. But there is still a controversy about any advantage of the silicone catheter regarding bacterial colonization rates and their biofilm production property.

Aims: The aim of our study was to compare the bacterial colonization and the biofilm formation property of the colonizing bacteria in patients with indwelling pure silicone and silicone coated latex catheters.

Materials and Methods: This prospective observational study was conducted in the Urology Department of our institute. Patients who needed catheterization for more than 5 days during the period July 2015 to January 2016 and had sterile precatheterisation urine were included in the study. Patients were grouped into 2 groups of 50 patients each, Group A with the pure silicone catheter and Group B with the silicone coated latex catheter. Urine culture was done on the 6th day of indwelling urinary catheter drainage. If growth was detected, then that bacterium was tested for biofilm production property by tissue culture plate method.

Statistical Analysis: Statistical analyses were performed using the Statistical Package for the Social Science Version 22 (SPSS-22).

Results: After 5 days of indwelling catheterization, the pure silicone catheter had significantly less bacterial colonization than the silicone coated latex catheter (p-value=0.03) and the biofilm forming property of colonizing bacteria was also significantly less in the pure silicone catheter as compared to the silicone coated latex catheter (p-value=0.02). There were no significant differences in the colonizing bacteria in the 2 groups. In both the groups the most common bacteria were *Escherichia coli*.

Conclusion: The pure silicone catheter is advantageous over the silicone coated latex catheter in terms of incidence of bacterial colonization as well as the biofilm formation and hence in the management of CAUTI.

Keywords: Catheter Associated Urinary Tract Infections, Pure silicone catheter, Silicone coated latex catheter

INTRODUCTION

Urinary catheters are a very important part of urology care. Catheter Associated Urinary Tract Infections (CAUTI) are one of the most common causes of nosocomial infections. Urinary tract infections constitute about 30% of nosocomial infections and about 75% of nosocomial urinary tract infections are associated with urinary catheters [1]. The incidence of bacteriuria in catheterized patients increases with increase in duration of catheterization [2]. Many bacterial species show biofilm mode of growth for their survival benefit in a wide range of clinical settings [3]. The most common organisms which commonly contaminate urinary catheter and develop biofilms are biofilm forming strains of *Escherichia coli, Pseudomonas aeruginosa, Enterococcus, Proteus mirabilis* and *Klebsiella pneumonia* [4]. These strains carry an array of adhesins in their walls and on contact with a surface; they secrete exopolysaccharides that promote their attachment. These bacteria then multiply and spread over the surface, forming colonies embedded in a gel-like polysaccharide matrix [3]. The bacteria in these biofilms have particular advantages. Biofilms lead to the persistence of microorganisms by providing protection for them from environmental stresses and it also leads to decreased susceptibility to antimicrobial agents [5].

The latex was the first material used for the manufacture of foley catheter, but there are some associated problems with latex including relatively poor biocompatibility and a susceptibility to infection and encrustation [6]. This led to the application of a range of different coatings to the surface of latex including the biocidal coatings such as silver coating; polymeric ones such as based on poly (2-hydroxyethyl methacrylate) (PHEMA), Polytetraflouroethylene (PTFE) and silicone [7]. Silicone which is considered one of the most biocompatible substances is also used in the manufacture of pure silicone catheter, made entirely of silicone [6].

Two most common types of catheters used in our setup are silicone coated latex catheter and pure silicone catheter. The advantage of pure silicone catheter for long term catheterization is well established [8]. There are limited studies comparing the pure silicone catheter and the silicone coated latex catheter in terms of bacterial colonization rates and the colonizing bacterial biofilm formation property and these studies also have conflicting results [6,7].

AIM

Therefore the study was conducted to elicit differences (if any) in colonization rates, causative bacteria and their biofilm production in patients with indwelling pure silicone and silicone coated latex catheters.

MATERIALS AND METHODS

This prospective observational study was conducted in the Urology Department of S.M.S Medical College and attached Hospitals, Jaipur, India our institution during the period July 2015 to January 2016. The approval was obtained from the ethics committee of our institute. Patients were grouped into 2 groups of 50 patients each, Group A with the pure silicone catheter and Group B with the silicone coated latex catheter.

Inclusion Criteria

Patients who needed indwelling catheterization for more than 5 days and had precatheterisation sterile urine were included in the study.

Exclusion Criteria

- Patients with urinary tract infection or bacterial growth on precatheterisation urine culture.
- Patients catheterised for less than 5 days.
- Immunocompromised patients.

Before catheterization, midstream urine was sent for culture under all aseptic conditions. If it came out sterile, then that patient was included in our study. First 50 patients with 16 French pure silicone catheter who fulfilled the inclusion criteria of our study were included in the Group A and the subsequent 50 patients with 16 French silicone coated latex catheter who fulfilled the inclusion criteria of our study were included in the Group B.

Closed catheter drainage was maintained and the catheter was positioned well secured to prevent any traction with urine collection bag always kept below the level of urinary bladder. Proper perineal hygiene was maintained. On the 6^{th} day of indwelling catheter drainage, urine sample was taken with the help of syringe and needle. Catheter drainage tubing was clamped to allow collection of freshly voided urine. After cleaning catheter port with 1% povidine iodine, a 21 gauze needle attached to the syringe was inserted in the catheter port between junction of drainage tubing and tubing from the balloon. Urine was aspirated into the syringe for culture. Urine sample was cultured on Blood agar and MacConkey agar with a calibrated loop delivering 0.001 ml of urine. Culture plates were incubated aerobically at 35°C for 18-24 hours [9]. Identification of the microorganism was done by colony morphology, gram's staining and biochemical reactions according to the standard laboratory protocols.

If growth was detected, then that bacterium was tested for biofilm formation property by Tissue culture plate method which is considered the gold-standard method for biofilm detection [10].

Organisms isolated from culture plates were inoculated in 10 ml of trypticase soy broth with 1% glucose and were incubated at 37°C for 24 hours. Free floating bacteria were removed by gentle tapping and washing with 0.2 ml of phosphate buffer saline (pH 7.2) four times. Adherent biofilm were detected by fixing with 2% sodium acetate and staining with 0.1% crystal violet [11].

Ethics

All procedures performed in studies were in accordance with the ethical standards of our institute and with the 1975 Helsinki Declaration and its later amendments.

STATISTICAL ANALYSIS

Data so collected was analysed using statistical software SPSS version 22. The Chi-Square test was used to test the significance of difference and the p-value ≤ 0.05 was considered as significant.

RESULTS

The results of our study showed that patients with indwelling silicone coated latex catheter for 5 days had significantly more bacterial colonization than patients with indwelling pure silicone catheter for 5 days.

There was a significant difference in biofilm production in the 2 groups [Table/Fig-1]. In patients with indwelling silicone coated latex catheter, 16 patients showed colonization with biofilm forming bacteria while in patients with indwelling pure silicone catheter, only 4 showed colonization with biofilm forming bacteria.

	Pure Silicone Catheter (n=50)	Silicone Coated Latex Catheter (n=50)	p-value
Number of patients with no bacterial colonization after 5 days of indwelling catheter drainage	38	28	0.03
Number of patients with bacterial colonization after 5 days of indwelling catheter drainage	12	22	0.03
Number of Uropathogens showing Biofilm formation	4	16	0.02

[Table/Fig-1]: Differences between the pure silicone catheter and the silicone coated latex catheter in bacterial colonization and biofilm formation after 5 days of indwelling catheter drainage.
n- total number of patients in the group.

The details of the bacterial species colonization in the 2 groups are shown in [Table/Fig-2] which clearly shows that were no significant differences in the colonizing bacteria in the 2 groups. In both the groups the most common bacteria were *E. coli* and the next most common bacteria were *Pseudomonas* and *Enterobacter.*

	Pure Silicone Catheter	Silicon Coated Latex Catheter	p-value
Bacterial colonisation	12	22	
Multiple organisms	3	4	0.638
E. coli	5	9	0.933
Pseudomonas	4	8	0.781
Enterobacter	4	7	0.986
Proteus	1	1	0.669
Citrobacter	1	0	0.182
Klebsiella	0	1	0.448

[Table/Fig-2]: Details of the bacterial species colonization in the 2 groups.

DISCUSSION

Urinary tract infections are one of the most common cause of hospital acquired infection constituting above 30% of all nosocomial infections. Urethral catheter is one of a major underlying factor in causation of nosocomial urinary tract infections. About 15-25% of all hospitalized patients require catheterization [1]. Nosocomial urinary tract infections may progress to gram negative septicaemia in 30-40% of patients [12]. Biofilms play an important role in its pathogenesis as it provides protection to the uropathogens from environmental stresses and it also leads to decreased susceptibility of the colonizing bacteria to the antimicrobial agents [13].

Most common forms of indwelling urethral catheters are the foley catheters, the basic design of which was first introduced in the mid 1930's by Dr. Fredrick B. Foley [14]. The original Foley catheter was manufactured from latex. Latex have many favourable properties like it can be easily processed and shaped, have good resistance to gouging, have relatively high tensile strength and have low costs [6]. There are few problems with latex like its poor biocompatibility and susceptibility to encrustation and infection [15]. The properties of latex, which favour it to be used as the constituent material for indwelling urinary catheters are difficult to be reproduced in any other material [6]. This has led to the application of different coatings to the surface of latex catheter to improve the problems associated with the latex. This includes the biocidal coatings such as silver coating; polymeric ones such as based on poly (2-hydroxyethyl methacrylate) (PHEMA), Polytetraflouroethylene (PTFE) and silicone [7]. All these coated catheters, according to the coating material have some added advantages like being more biocompatible, less susceptible to bacterial colonization, less susceptible to encrustation or better lubrication [6]. However, mixed results about the effects of surface coatings on the bacterial colonization and encrustation were obtained [6,7].

The two most commonly used materials for the Foley catheter in our setup are silicone coated latex and pure silicone. Silicone coated latex and pure silicone catheters have been thought to be potential solutions for catheter-related complications. The silicone coating on the latex improves the biocompatibility of the catheter and decreases the tissue inflammation. Silicone possesses few properties which favour it to be used as the entire constituent of the urethral catheter like it has mechanical strength and elasticity required by a catheter [6]. Also, it has greater rigidity, so that pure silicone catheters have relatively thin wall, thus creating a larger drainage lumen and it takes longer time to encrust and block [6,16]. However, the disadvantage of pure silicone catheter is that it is more expensive [17] and causes more discomfort to the patients due to its more rigidity [18]. Any advantage of the pure silicone catheter in terms of bacterial colonization and biofilm formation is still a matter of debate.

Our study showed that the bacterial colonization rates in pure silicone catheter after 5 days of indwelling catheterization were significantly less as compared to the silicone coated latex catheter. Also, colonization by biofilm producing bacteria was significantly less in patients with indwelling pure silicone catheter as compared to silicone coated latex catheter. Studies in literature have shown conflicting results regarding benefit of pure silicone catheter in terms of bacterial colonization and biofilm formation. Similar to our study, the study conducted by Sabbuba et al., have shown the superiority of pure silicone catheter [19]. While the study conducted by Gabriel et al., showed that there was no advantage of pure silicone catheter in terms of bacterial colonization [20]. The study conducted by Morris et al., showed that pure silicone catheter was not advantageous in resisting bacterial colonization and the biofilm formation [16].

While the study conducted by Kumon et al., showed that silicone is superior in terms of bacterial colonization and biofilm formation [21]. A study conducted by Lawrence et al., have shown that the surfaces of pure silicone catheter is smoother than the silicone coated latex catheter and also it shows little change over time while silicone coated latex catheter showed peeling from the underlying latex substrate possibly because of a mismatch in moduli between coating and substrate [22]. This could be the possible reason for the superiority of the pure silicone catheter over the silicone coated latex catheter in terms of bacterial colonization and biofilm formation.

An indwelling urinary catheter is a very important aspect of patient management, but it has some inherent complications. One of the most important among these is bacterial colonization which can lead to CAUTI which may further progress to urosepsis. Biofilms play an important role in this progression as it provides protection to the colonizing bacteria and causes decreased susceptibility to antimicrobial agents. In patients with indwelling urinary catheter, preventing bacterial colonization and biofilm formation is a big challenge. There have been many attempts for last many decades to alleviate this problem like introduction of various catheter coatings and new constituent catheter material. Our study showed that pure silicone catheter is advantageous over the most commonly used silicone coated latex catheter in terms of bacterial colonization and biofilm formation, although it didn't completely resist the bacterial colonization and the biofilm formation.

LIMITATION

There are a few limitations of our study as it is a single centre study and the sample size is small. Further studies should be designed in the future to validate our results. Further future attempts should be made to introduce new biomaterials and the catheter designs to find possible solutions to the problem of bacterial colonization and the biofilm formation.

CONCLUSION

Any advantage of the pure silicone catheter over the most commonly used silicone coated latex catheter in terms of CAUTI is still a matter of debate. The pure silicone catheter is advantageous over the silicone coated latex catheter in terms of incidence of the bacterial colonization as well as the biofilm formation (which have an important bearing on the management of CAUTI). Further studies are required to validate our results.

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