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RESEARCH ARTICLE

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Efficacy of Silver Coated Foley's Catheter in Comparison with Latex Foley's Catheter for Prevention of Antimicrobial Resistance and Catheter Associated Urinary Tract Infections in Obstructive Urolithiasis of Male Buffalo Calves

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ABSTRACT

Background: Foley's catheters are widely used for treating obstructive urolithiasis and are often associated with high rate of urinary tract infections. The urinary catheters act as a platform for colonization and biofilm formation by pathogens, leads to increasing the risk of catheter associated bacterial infections.

Methods: The present study was aimed to address the antimicrobial activity and biofilm inhibition effect of silver Foley's catheter in male buffalo calves suffering from obstructive urolithiasis. The study was conducted on twelve male buffalo calves suffering from obstructive urolithiasis, randomly divided into two groups irrespective of their age *viz.,* group I (latex Foley's catheter treatment) and group II (silver hydrogel coated Foley's catheter treatment). Cultural examination and antibiotic sensitivity of cultured bacteria from the urine passed through fixed urinary catheter was performed at 0th, 7th, 14th and 28th postoperative days in both the groups.

Result: There was significant reduction in growth of bacteria like Streptococcus, *Staphylococcus* and *E. coli* bacterial colony formation on blood agar and MacConkey lactose agar, respectively in silver catheter group as compare to latex catheter group from day 0 to day 28th. The zone of inhibition was more pronounced for both antibiotics *viz.,* Cefotaxime and Ceftriaxone (upto 24 mm) in urine samples collected from silver hydrogel coated Foley's catheter as compared to latex Foley's catheter indicating its biofilm inhibition effect on bacteria. Silver-hydrogel Foley's Catheter are more cost-effective as compare to latex Foley's catheter.

Key words: Culture sensitivity, Silver, Resistance, Urinary catheter, Zone of inhibition.

INTRODUCTION

Indwelling urethral catheter used to treat obstructive urolithiasis in male buffalo calves are the primary cause of urinary tract infections contributing approximately 70-80% of acquired infections (Zarb *et al.,* 2012 and Magill *et al.,* 2014). The most commonly found infecting organism is *Escherichia coli* specially in Urinary tract infections of humans. (Hooton *et al.,* 2010 and Arnoldo *et al.,* 2013). Other bacteria include coagulase negative *Staphylococcus, Streptococcus* and *Pseudomonas aeruginosa* are also isolated (Nicolle, 2012). Untreated urinary tract infection due to biofilm formation along the catheter surface can lead to local or systemic bacteuria (Stickler 2008). Biofilm is a complex organic material consisting of microorganisms specially which produces urease enzyme help in formation of an extracellular mucopolysaccharide substance which is crystalline in nature and appeared just like a struvite (Nicolle, 2014, Getliffe and Mulhall, 1991). which increases morbidity, predisposes animals to sepsis, harbours drug resistance, adds to increased health care costs and possibly leads to death (Maki *et al.,* 2001 and Saint *et al.,* 2002). The proposed methods to prevent catheter associated urinary tract infection (CAUTI) includes use of proper aseptic technique during catheter insertion, shortening the time interval for catheter use (Cornia *et al.,* 2003) or manipulation of catheter

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surfaces with antimicrobials and noble metals like silver, gold and palladium (Siddiq *et al.,* 2012). Silver is one of the biomaterials approved by Food and drug administration (FDA) as urinary catheter coating for prevention of UTI. Silver increases the permeability of bacterial cells by increasing the membrane potential. Silver particles that penetrate the bacteria causes cell protein denaturation, results into dissociation of iron-sulphur clusters, this iron component causes oxidative stress on the pathogens leading to cell death (Majeed *et al.,* 2019). The cost of these noble metals impregnated catheters like silver Foley's catheter is more as compared to normal latex catheter's but justifiable, as the cost of post-operative antibiotics reduces due to the presence of indwelling catheters which prevent the bacteria to produce antimicrobial resistance.

MATERIALS AND METHODS

The research was carried out from October 2019 to December 2020 on twelve male buffalo calves aged from birth upto 6 months which are presented in Department of Veterinary Surgery and Radiology, College of Veterinary Sciences, LUVAS, Hisar, Haryana with the history of straining during urination, abdominal distension with pain, dribbling of urine, bleating of teeth and tail and kicking at belly etc. The calves were randomly divided into two groups comprising of six calves in each group irrespective of their weight and breed. In group-I, tube cystostomy was performed for management of obstructive urolithiasis using latex Foley's catheter, whereas the tube cystostomy was performed for management of obstructive urolithiasis using silver coated Foley's catheter in group-II animals.

In all the cases no complication during surgery was observed and tube cystotomy was performed found safe, reliable technique for retention of urine in buffalo calves. Tube cystotomy include simple procedure, preservation of the reproductive function of the animal and less tendency of recurrences of retention of urine (May *et al*., 1998). The silver hydrogel Foley's catheter and latex coated Foley's catheter was fixed inside the bladder by putting 30 ml of normal saline to inflate the balloon and prevent backward movement of catheter in group I and group II respectively. The underlying muscles, subcutaneous fascia and skin were closed in routine manner after passing the catheter through a subcutaneous tunnel. Post-operatively, the animals were kept under close observations given antibiotics and NSAIDS intramuscularly in non-uniform climatic conditions for 28 days for recording any kind of complications like urethral leakage, blockade, dislodgement of catheter, re-obstruction, suture dehiscence and pus discharge, if any. The urinary catheter was kept closed with needle cap to prevent any external environment infection as much possible to certain extent and open only at the time of urination and sample collection.

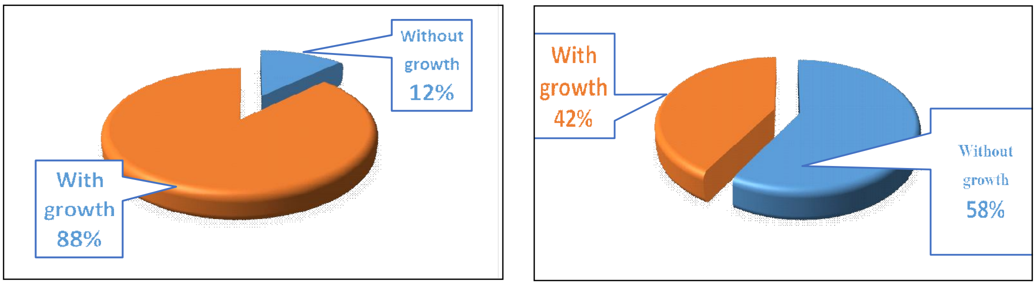
Microbiological examination of urine

Urine samples were collected aseptically through tube cystostomy Foley's catheter postoperatively after removing the needle cap in 5ml sterile syringes on 0th, 7th, 14th and 28th day in both the groups (Group I and II). Total 48 samples were collected from both groups. From each animal, 2-3 ml urine was collected aseptically in sterile test tube from respective catheter for microbiological examination. The urine sample was cultured for their growth on 90 mm plates of MacConkey lactose agar for *E. coli* and *Klebsiella* sp.; and blood agar for *Streptococcus* sp. and *Staphylococcus* sp. of bacteria respectively. Bacteria are differentiated on the basis of morphological characteristics with the help of gram staining as well as cultural characteristics on the plate seen on simple microscope under 100X and further under contrast microscope. Isolated bacteria were residing in the nutrient broth and then incubate for 4-5 hrs till turbidity appears inside it. After incubation, bacterial broth was streaked on the blood agar, antibiotic discs of cefotaxime and ceftriaxone were placed on the streaked broth of bacteria. After 24 hrs incubation, the zone of inhibition and sensitivity of bacteria was observed against the respective antibiotics.

RESULTS AND DISCUSSION

Microbiological examination

Microbiological findings were represented in the form of pie diagrams and on agar plates depicting results from group I and II subjected to antibiotic sensitivity testing after bacterial culture over blood agar and MacConkey agar. In group I, twenty-one (88%) samples showed growth while three samples (12%) showed no growth of bacteria after incubation over respective agar media at various day interval from day 0 to day 28th (Fig 1 and Table 1). In group II, from day 0 to day 28th thirteen samples (42%) showed growth



(a) Group- I (Latex Foley's Catheter) (b) Group-II (Silver Coated Latex Foley's Catheter)

Fig 1: Bacterial growth over MLA and Blood agar media in Group I and II.

while eleven samples (58%) showed no growth after incubation over respective agar media (Fig 1 and Table 2). These findings correlated with Schumm and Lam (2008) where they concluded that silver alloy urinary catheters appear more effective than standard catheters at reducing bacteriuria in patients who require short-term catheterisation. Similarly, five types of bacteria were isolated after culture on MacConkey lactose agar and blood agar in group I, while three types of bacteria were isolated in group II on respective agar. On collection of 24 samples at day 0, 7th, 14th and 28th from each calf of group I, *Staphylococcus* was most common in 11 (45%) samples, followed by *Streptococcus* in 6 (22%), *E. coli* in 4 (19%), *Klebsiella* in 2 (8%) and *Bacillus* in 1(6%). Out of 24 samples collected from day 0 to day 28th in group II, *Staphylococcus* 13(54%) and *Streptococcus* 10 (41%) were most commonly found followed by *E. coli* in 4 (16.6%) samples. No *Klebsiella* and *Bacillus* spp. were found in group II. In both groups *Staphylococcus* was most commonly found bacteria followed by *Streptococcus*, *E. coli* and *Klebsiella* which correlated with study conducted by Rupp *et al.* (2004) which stated that there is 57% symptomatic UTI and 43% asymptomatic UTI caused by coagulase negative *Staphylococcus*, *E. coli* and *Klebsiella* bacteria. Modak *et al.* (1973) delineated that *Pseudomonas* and *Gonococci* are more susceptible to silver ions than *Staphylococci*. This is due to the thin murein wall of gram-negative bacteria (2-3 nm) in comparison to the greater thickness of murein in gram-positive bacteria (10 nm) as silver ion bound to the murein by adsorption processes induces bacteriostatic effects, whereas at higher silver ion concentrations, bactericidal effects are achieved by silver-DNA-chelate complexes, which corroborates our findings of reducted *Klebsiella* infection in group II than in group I. Hachem *et al.* (2009) reported that silver -hydrogel urinary catheter has limited activity on inhibiting the growth of *E. coli* bacteria which supported our findings in our both groups as silver catheter is ineffective in controlling the infections caused by *E. coli*.

The zone of beta-haemolysis was observed on blood agar having golden yellow colonies of *Staphylococcus* and whitish mucoid colonies of *Streptococcus* in both the groups (Fig 2a). On MacConkey lactose agar, circular smooth colonies of *E. coli* were observed (Fig 2b) with appearance of flat and dark pink due to lactose fermentation and pale

Table 1: Culture sensitivity and antibiotic resistance at different time intervals in male buffalo calves with obstructive urolithiasis in Group-I.

Animal	Day 0	Day 7	Day 14	Day 28
1	*Staphylococcus* AST- R ZOI- 13 mm^{CE}	*Staphylococcus* AST- R ZOI- 14 mm^{CE}	*Staphylococcus* *Streptococcus* AST- R ZOI- 12 mm^{CE}	NA
2	*Streptococcus* AST- R ZOI- 15 mm^{CE} ZOI-14 mm^{CTR}	*Staphylococcus* AST- R ZOI- 13 mm^{CE} ZOI-14 mm^{CTR}	NA	*Streptococcus* AST- R ZOI- absent
3	*E. coli*, *Klebsiella* *Staphylococcus* AST-R ZOI- 13mm^{CE} ZOI-11mm^{CTR}	*E.coli* AST- R ZOI- 12 mm^{CE} ZOI-11 mm^{CTR}	*Streptococcus* AST- R ZOI- absent	*Staphylococcus* AST- R ZOI- absent
4	*Klebsiella* *Staphylococcus* AST-R ZOI- 15 mm^{CE} ZOI-11 mm^{CTR}	*Streptococcus* AST-S ZOI- 23 mm^{CE} ZOI-21 mm^{CTR}	*Staphylococcus* AST-S ZOI- 23 mm^{CE} ZOI-21 mm^{CTR}	*Staphylococcus* AST-S ZOI-23 mm^{CE} ZOI-21 mm^{CTR}
5	E. *coli* AST-R ZOI- 11 mm^{CE} ZOI-10 mm^{CTR}	*Bacillus* AST-R ZOI- 13 mm^{CE}	*Staphylococcus* AST-R ZOI- 10 mm^{CE} ZOI-13 mm^{CTR}	NA
6	*Staphylococcus* AST-R ZOI- 14 mm^{CE} ZOI-11 mm^{CTR}	*Streptococcus* AST-S ZOI-19 mm^{CE} ZOI-20 mm^{CTR}	E. *coli* AST-S ZOI-19 mm^{CE} ZOI-20 mm^{CTR}	*Streptococcus* AST-R ZOI-19 mm^{CE} ZOI-20 mm^{CTR}

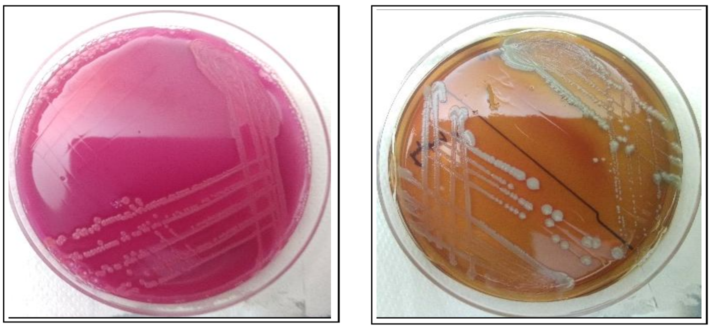
ZOI: Zone of inhibition, AST: Antibiotic sensitivity test; CE: Cefotaxime, CTR: Ceftriaxone, R: Resistance, S: Sensitive, NA: No growth.

pink mucoid colonies of *Klebsiella* (Fig 3). In group I, colonies of *Bacillus* (Fig 4) were found in one sample having characteristics like non-haemolytic, flat, slightly convex with irregular edges on blood agar. Cultured bacteria were observed microscopically at 100X found elongated rod-shape *Bacillus* (Fig 5a), gram negative, non-motile and rod-shaped *E. coli* (Fig 5b) along with *Klebsiella* (Fig 5c). Contrast microscopy of cultured bacteria showed twisted

Table 2: Culture sensitivity and antibiotic resistance at different time intervals in male buffalo calves with obstructive urolithiasis in group-II.

Animals	Day 0	Day 7	Day 14	Day 28
1	NA	*Staphylococcus* *Streptococcus* AST-R ZOI- 13 mm^{CE} ZOI-14 mm^{CTR}	*Staphylococcus* AST-S ZOI- 23 mm^{CE} ZOI-21 mm^{CTR}	NA
2	NA	E.*Coli* *Streptococcus* *Staphylococcus* AST- S ZOI- 19 mm^{CE} and 18 mm^{CTR}	*E.coli* *Staphylococcus* AST- S ZOI- 23 mm^{CE} and 21 mm^{CTR}	NA NA
3	NA	*Streptococcus* *Staphylococcus* AST-S ZOI- 20 mm^{CE} and 19 mm^{CTR}	*Streptococcus* *Staphylococcus* AST-S ZOI- 19 mm^{CE} and 18 mm^{CTR}	
4	NA	E. *coli* *Streptococcus* *Staphylococcus* AST-R ZOI- 11 mm^{CE} ZOI-13 mm^{CTR}	*Staphylococcus* *Streptococcus* AST-S ZOI- 26 mm^{CE} and 23 mm^{CTR}	NA
5	*E. coli* *Staphylococcus* *Streptococcus* AST-R ZOI- 13 mm^{CE} ZOI-11 mm^{CTR}	*Staphylococcus* *Streptococcus* AST-S ZOI- 17 mm^{CE} and 18 mm^{CTR}	*Staphylococcus* *Streptococcus* AST-S ZOI- 20 mm^{CE} and 21 mm^{CTR}	NA
6	*Staphylococcus* *Streptococcus* AST-R ZOI- 10 mm^{CE} ZOI-13 mm^{CTR}	*Staphylococcus*, AST-S ZOI- 25 mm^{CE} and 24 mm^{CTR}	NA	NA

ZOI: Zone of Inhibition, AST: Antibiotic Sensitivity Test; CE: Cefotaxime, CTR: Ceftriaxone, R: Resistance, S: Sensitive, NA: No growth.



(a) *E. coli* colonies on MacConkey lactose agar

(b) *Staphylococcus* and *Streptococcus* colonies on Blood agar

Fig 2: Bacterial growth over agar medium.

bunch of round berries of *Streptococcus* (Fig 6a) and round and forms grape like clusters of *Staphylococcus* (Fig 6b) along with rod-shape non-motile *E. coli* (Fig 7) were observed. In group I, five samples were found to be sensitive (Zone of inhibition was above 15 mm) to both Cefotaxime and Ceftriaxone (Fig 8), however resistance or no growth (Zone of inhibition was observed below 15mm) was reported in 16 samples. In group II, 9 samples were found to be sensitive to both Cefotaxime and Ceftriaxone, however 15 samples were showed either no growth or resistance to antibiotics (Fig 9). This is in correlation with Schierholz *et al.* (1998) where they showed in their study that silver coated central venous catheter reduced the infection rate by 50% although there was no reduction of catheter colonization or catheter associated sepsis.

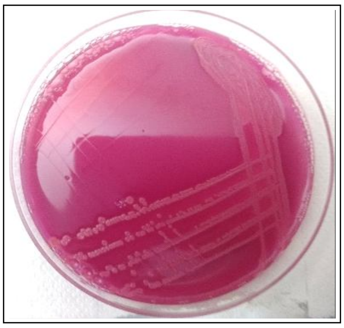


Fig 3: Colonies of *Klebsiella* in MLA.

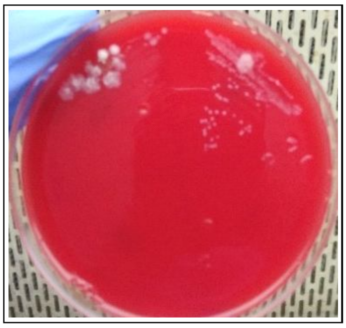
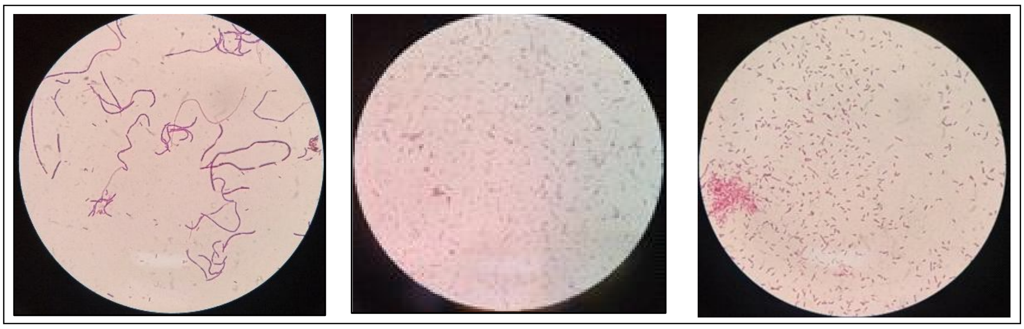


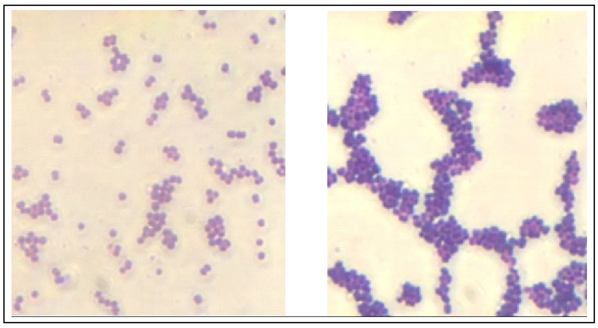
Fig 4: Colonies of *Bacillus* in Blood agar.

In group I, seventeen (70%) samples collected at different scheduled day of study showed gram positive cocci and seven (29%) showed gram negative rods of which five were sensitive and other sixteen were resistant to both antibiotics. The trend showed zone of inhibition decreased from day 0^{th} to day 28^{th} postoperatively in four cases and nearly constant in two cases (Table 1). In group II, thirteen samples (54%) showed gram positive cocci and four (16%) showed gram negative rods of which six were found sensitive and other four samples were resistant to both cefotaxime and ceftriaxone. The zone of inhibition was increases or absent and going upto 22 to 25 mm as we move from day 0^{th} to day 28^{th} in five cases decreases slightly in one case (Table 2). So, overall sensitivity to both antibiotics against bacteria was more in group having silver coated latex Foley's catheter. Maki *et al.* (2001) recorded that use of catheters coated with antimicrobial agents or antiseptics using technologies which help in releasing of ionic silver into the aqueous environment may assist in prevention of CAUTIs caused by intraluminal organisms. The findings of this study are in correlation with the Rupp *et al.* (2004) where they reported that there is 56% decrease in CAUTI'S (Catheter associated urinary tract infection) in silver alloys catheters. Ogilvie *et al.* (2018) confirmed in his study of using silver catheter in preventing catheter associated urinary tract infections in short term (<48 hrs) was quite significant as compare to non-silver catheters. Karchmer *et al.* (2000) also reported reduction in the rate of catheter-associated UTI has ranged from 27% to 73% in his randomized trials involving the silver alloy/hydrogel-coated urinary catheter. The total cost of silver hydrogel coated Foley's catheter is around 6000 INR for six animals in group II as compare to the cost 1000 INR for latex foley's catheter in group II is totally defensible as the post-operative cost for antibiotics is reduced due to the ability of silver in preventing bacteria for making biofilm, hence reduced the reoccurrence of antimicrobial resistance from day 7^{th} to day 28^{th} in group II (Table 2) as compare to group I (Table I). The results of our study is supported by the findings of Rupp *et al.* (2004) which stated direct cost savings achieved through the use of the coated urinary catheter as compare to uncoated catheters.



(a) Bacillus *(b) E. coli* *(c) klebsiella*

Fig 5: Microscopic view of bacteria's.



(a) *Streptococcus* b) *Staphylococcus*

Fig 6: Contrast microscopic view of bacteria's.

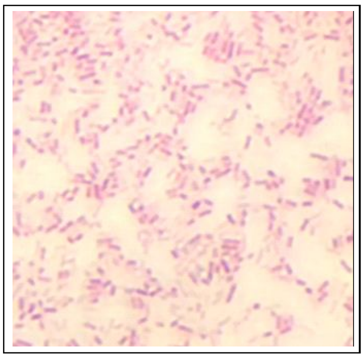


Fig 7: Contrast microscopic view of *E. coli*.

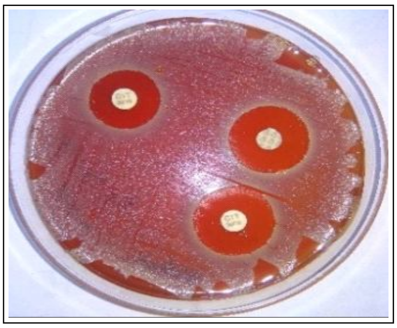


Fig 8: Culture sensitivity of bacteria showing zone of inhibition less than 15mm for both ceftriaxone and cefotaxime in latex catheter case.

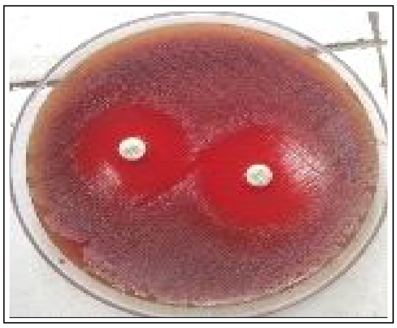


Fig 9: Culture sensitivity of bacteria showing zone of inhibition more than 25 mm for both ceftriaxone and cefotaxime in silver catheter cases.

CONCLUSION

It can be concluded from the results of our study that silver coating of Foley's catheter resulted in marked increase in zone of bacterial inhibition and decrease in antibiotic resistance against bacteria during obstructive urolithiasis treatment in buffalo calves. The antifouling agents like silver helps in prevention of adhesions and aggregation of pathogens along with prevention of biofilm formation, thereby increasing sensitivity of bacteria against pathogens.

Conflict of interest: None.

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