Role of silver nanoparticle impregnated SilvoGuard® urinary catheter in management of CAUTI: A pilot study

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Abstract
Urinary catheters are meant for measuring the urine output of patients. Urine output is a very sensitive tool to know the hemodynamic status of the patient and also to assess the renal blood flow. The urinary catheter can be associated with urinary tract infection. If kept *in situ* for a prolonged time, it can result in catheter associated urinary tract infection (CAUTI). CAUTIs are associated with increased health care cost, prolonged stay in hospital and increased mortality. Recently, we have come across the utility of silver nanoparticle impregnated Foley catheter; SilvoGuard® and found it to be useful in reducing CAUTI events in patients.

Keywords: Silver nanoparticles, Silver impregnated catheter, Burn patient.

Introduction
Catheter-associated urinary tract infection (CAUTI) is one of the most common healthcare-acquired infections (HAI) accounting for approximately one-third of all device-related infections and 40% of infections hospital-wide.[1-3] According to Centre for disease prevention and control (CDC), CAUTI is defined by a positive urine culture (bacteriuria) with atleast one phenotypic symptom. The incidence of bacteriuria associated with indwelling Foley catheters is 3% - 8% per day. The duration of catheterization is the most important risk factor for the development of CA-bacteriuria. To reduce the incidence of CAUTI several catheters coated with silver ions or antibiotics are developed. Silver (Ag) is a nonspecific bactericide that can act against a broad spectrum of bacterial species even at very low concentrations. Various methods have been used for the prevention of CAUTI in patients including improvements in the sterile technique for catheter insertion, using silicone catheters, Using silver-coated catheters, etc. Here we performed a pilot study to assess the efficacy of silver nanoparticle impregnated SilvoGuard® Foley catheter in reducing catheter associated UTI based on urine culture tests.

Materials and Methods
The study is a pilot study conducted in the Burns ICU of a tertiary care hospital. The study was conducted after getting the departmental ethics committee approval. SilvoGuard® is a Foley catheter (Latex) impregnated with silver nanoparticles by patented NanoAgCide™ technology for the prevention of the infection. The catheter is available in sizes of Fr 6 to 24 with balloon size of 5 and 30ml and are sterilized. The burn patients were selected on a convenient basis for the study after getting informed written consent. Patients were inserted with the new SilvoGuard® catheters at admission or when there was a urinary catheter change, all under aseptic precaution by trained nurses or doctors. Two evaluation points were considered for the study, first, urinary culture at the time of catheterization and second urinary culture after 7 to 10 days of the catheter *in situ*. Final outcome for the incidence of CAUTI was assessed by comparing the urinary culture reports of the two evaluation points considered. The feedback was taken from the nurses and doctors who catheterized the patients.

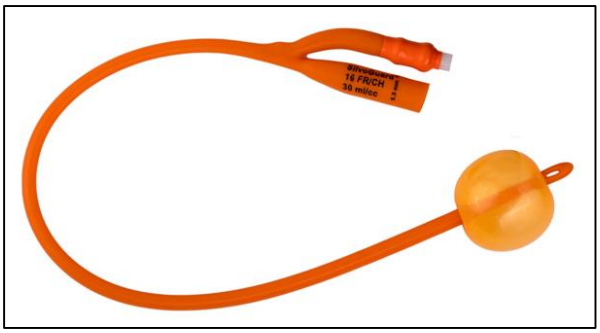

Fig. 1: SilvoGuard® Foley Balloon catheter

Table 1: Urine culture testing at catheterization

Patient	Gram stain	KOH examination	Organism	Remarks
Patient 1	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified
Patient 2	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified
Patient 3	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified

Patient 4	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified
Patient 5	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified

Table 2: Urine culture testing after 10 days of catheterization

Patient	Gram stain	KOH examination	Organism	Remarks
Patient 1	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified
Patient 2	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified
Patient 3	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified
Patient 4	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified
Patient 5	Organism not apparent	No fungal growth	No organism isolated after overnight incubation under aerobic condition	Sensitivity could not be reported as no growth has been identified

Table 3: Health care worker and their experience on scale of 1 to 5 rating, the higher the score the more was the satisfaction level

Health Care Worker (HCW)	Ease of usage	Reliability	Recommendation for others for usage	Effective in protection against CAUTI
HCW 1	4	4	No	Yes
HCW 2	4	4	Yes	Yes
HCW3	5	4	Yes	Yes
HCW 4	4	4	Yes	Yes
HCW 5	4	4	Yes	Yes

Table 4: Feedback form

Questionnaire	Rating 1 to 5 (1 being worst , 5 being best)
How was the ease in using SilvoGuard® urinary catheter	
How was the reliability of using the SilvoGuard® urinary catheter	
Will you recommend it for using the SilvoGuard® urinary catheter	Yes/No
Is the SilvoGuard® effective in protection against CAUTI	Yes/No
Suggestions, if any	

Results

A total of 5 patients underwent urinary catheterization with the SilvoGuard® Foley catheter out of which 4 patients were already on catheter replaced by SilvoGuard® catheter and 1 was a new patient. The comparison of urine culture reports demonstrate that the cultures were sterile at the end of 7 to 10 days in the patients catheterized with SilvoGuard® Foley balloon catheter. None of the symptoms related to CAUTI were observed in the patients catheterized with SilvoGuard® Foley catheter

Discussion

A urinary tract infection (UTI) is an infection involving any part of the urinary system, including the urethra, bladder, ureters, and kidney. UTIs are the most common type of healthcare-associated infection reported to the National Healthcare Safety Network (NHSN). Among UTIs acquired in the hospital, approximately 75% are associated with a urinary catheter, which is a tube inserted into the bladder through the urethra to drain urine. Between 15-25% of patients receive urinary catheters during their hospital stay. The most important risk factor for developing a catheter-associated UTI (CAUTI) is the prolonged use of the urinary catheter.

Silver is a broad-spectrum antimicrobial agent that exhibits activity against both bacteria and fungi without inducing resistance.[4,5] There are three known mechanisms by which silver acts on microbes. Firstly, silver cations can form pores and puncture the bacterial cell wall by reacting with the peptidoglycan component [6]. Secondly, silver ions can enter into the bacterial cell, both inhibiting cellular respiration and disrupting metabolic pathways resulting in the generation of reactive oxygen species.[7] Lastly, once inside the cell, silver can also disrupt DNA and its replication cycles.[8] A wide variety of antibiotics and antiseptics have been used to coat urinary catheters with varying degrees of success. Catheters coated with silver alloy/hydrogel have recently been introduced into practice, and a growing body of literature

supports their use in a variety of clinical settings. A meta-analysis of prospective trials supported the efficacy of the silver alloy/hydrogel-coated catheter, 4,8

NanoAgCide™ is a new patented technology of making active silver nano particles which are non-toxic and safe. These nanoparticles are used in SilvoGuard® Foley catheter and can be used in any type of raw material for making the medical devices antimicrobial. Specific stabilizing agents used during manufacturing make the nanoparticles stable and uniformly compounded in various materials. The compounding does not allow nanoparticles to leach out of the final product making it more environment friendly.

We have used the SilvoGuard® catheters impregnated with silver nanoparticles synthesized using patented NanoAgCide™ technology for the prevention of CAUTI in our patients. We found that SilvoGuard® was effective as none of the patient enrolled in the study showed incidence of CAUTI . The SilvoGuard® catheter is not only antimicrobial but also has unique features for patient and doctors comfort. The catheter is economical and affordable to the patients and hospitals as compared to other antimicrobial catheters. SilvoGuard® helps in reducing Hospital acquired infections However, the overall hospital cost due to the development of CAUTI needs to be assessed (HAIs). The doctors and nurses were satisfied with the usage of the SilvoGuard® catheter as it was easy to use and handle.

The current study was a pilot study and can be tested on a large population with randomized clinical trial and statistical analysis.

Conflict of Interest

The authors declare that there are no conflicts of interest in this paper.

Source of Funding

None.

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