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Urology

EVOLUTION OF ENCRUSTATIONS ON DOUBLE J STENTS-A FOURIER TRANSFORM SPECTROSCOPY ANALYSIS

Suresh Bhat	Professor Dept of Urology Government Medical College Kottayam Kerala 686008
Fredrick Paul	Associate Professor Department of urology Government Medical College Kottayam Kerala 686008
Ramaprasad M K	Consultant Urologist Aster Medicity Hospital Cochin
Suyog Shetty	Resident Department of Urology Government Medical College Kottayam Kerala 686008
Sabu Thomas	Director International and Interuniversity Centre for Nanosciences and Nanotechnology Mahatma Gandhi University Kottayam 686560

ABSTRACT Stenting of the ureter is one of the most commonly performed urological procedures. Double J ureteric stents used for this purpose are associated with many morbidities like frequency, urgency, dysuria, hematuria, stent migration, stent fracture and stent encrustation. In this study we evaluated the temporal relationship of the evolution of stent encrustation. Ureteric stents that were indwelling for a period of 2weeks, 6weeks and 12weeks were studied using Fourier-transform infrared spectroscopy(FTIR). A fresh stent was used as a control. In our study it was noted that additional amide peaks occur as one of the first changes. Another notable change occurring in the stent is appearance of carboxylic acid peaks suggesting a deposition of proteins as early as 6 weeks which maybe the precursor for stent encrustation. Another notable change was the disappearance of peaks around 2349 cm -1 region denotes phosphines these Phosphines are organophosphorus compounds with P-H bonds. Hence there is a pressing need for a further studies into the deleterious effects of the dissipation of these stent materials into the patient.

KEYWORDS : Stent,Ureteric Stent, Encrustation, Fourier-transform infrared spectroscopy

INTRODUCTION

Double J ureteric stents are being used in urological practice since 1978.Though they are life saving many a time, long term usage is associated with complications like infection, encrustation, pain, reflux, migration etc. There have been many attempts at reducing these morbidities to make its use safer. Research has shown the development of biofilm, encrustation on the stent and stent leaching can have deleterious effect on the host. There are a few experimental and clinical studies analyzing the changes occurring on the D J stents.(1,2) The methods used for the analysis include biochemical semi-quantitative analysis, polarizing optical microscopy, Fourier-transform infrared spectroscopy(FTIR), X-ray diffraction, scanning electron microscopy and energy-dispersive X-ray analysis. Many of these studies are conducted in solutions to mimic urine in laboratory settings.(1,2,3,4) The studies have focused on the formation of biofilms and its nature, chemical nature of encrustations, the dynamics of flow and the clinical management of encrusted stents. The objective of the present study was to analyze the pattern and temporal relationship of the changes occurring on the double J stent in human body using FTIR spectroscopy.

MATERIALS AND METHODS:

The study was conducted in the department of Urology, in a tertiary care hospital in collaboration with department of chemical sciences of a reputed university. We studied stents made of Tecoflex produced by one particular manufacturer. Tecoflex is a family of medical-grade aliphatic polyether polyurethanes. They are available over a wide range of colors and radio-opacifiers, including barium sulfate, bismuth salts. Out of five grades, the most popular grade consists of EG-93A-B40, which is used for most of the medical short term implant products.

Six used DJ stents, 2 each, of an indwelling period of 2 weeks,6weeks and 12weeks were analyzed using FT IR spectroscopy . The pelvic end and the bladder end were studied separately to know if there is any difference. The relevant details of the patients from whom the stents were collected for the study are given in Table 1. In addition, a new stent was analysed as a control.

TABLE 1

Groups based on stent indwelling period	Indication for stenting	Patient characteristics
Group 1 : 2 weeks	Patient 1 : Upper ureteric stone	38 years / Male
	Patient 2 : Upper ureteric stone	41 years / Male
Group 2 : 6 weeks	Patient 1 : pelvic stone	42 years / Male
	Patient 2 : pelvic stone	50 years / Male
Group 3 : 12 weeks	Patient 1 : pelvic stone	49 years / Male
	Patient 2 : middle calyceal stone	48 years / Male

RESULTS

Analysis of new stent :

Detailed analysis of unused stent showed presence of the following groups: alkenes, alkynes, amine, aldehyde, phenol, carboxylic acid, ketone, sulfate, silane, ester, nitro and phosphine.

Analysis of Bladder End of used stents :

In Group 1, the stents showed peaks at 1614 cm-1 (amide group) and loss of peak at 1690 cm-1 in one stent. Group 2 showed peaks at 1612(amide group) and 2348 cm-1 (phosphine group) with loss of peak at 1690 cm-1 in one stent. In Group 3, stents showed peaks at 1715 cm-1, 1606 cm -1, 1676 cm-1, 1638 cm -1, 2349 cm -1, 2299 cm -1, 2376 cm -1 and 2349 cm -1 denoting carboxylic acid, amide and phosphine groups.

Analysis of pelvic end of used stents :

In Group 1, 1715 cm-1 and 1608 cm-1 (amide and carboxylic acid) peaks appear. In Group 2, one stent showed peak at 1634 cm -1(amide) and another at 1714 cm-1(carboxylic acid). Peak at 1690 cm-1 was lost in one of the stent. In Group 3, peaks were detected at 1715 cm -1 (carboxylic acid) and 1674 cm -1, 1676 cm -1(amide).

The above analysis reveals changes occurring in the stent over time. One of the changes which occurs early is the appearance of additional amide groups peaks. This is followed by appearance of more carboxylic acid peaks and then loss of phosphine peak. The loss of peak at 1690 cm -1 may be due to changes occurring in the stent material.

DISCUSSION:

Ureteral stents are also called as “right hand men” for the urosurgeons. Stenting of the ureter is one of the most commonly done procedures by

a urologist. It is a life saving procedure when done in a patient with upper urinary tract obstruction and infection. It also used in various reconstructive procedures like pyeloplasty, ureteric reimplantation, ureteroureterostomy etc wherein they are kept indwelling for a varying period of 2-6 weeks. In conditions of obstructive uropathy due to malignancies, they are kept for longer duration.

The short and long term usage of ureteric stents are not without side effects. The complications include frequency of urination, dysuria, hematuria, infection, pain, encrustation, migration of the stent , reflux etc. The lower urinary tract symptoms are managed with alfa blockers. However, recurrent infection due to biofilm formation and encrustation of the stent are difficult to manage.

According to the basic biochemistry, amines and carboxylic acid occurs in amino acids.The amine groups react with carboxylic acid leading to amide formation. It is known that the early encrustations occur on biofilms formed on stents which contains about 300 types of proteins including histones, immunoglobulins and Tamm-Horsfall proteins(5). In our study it was noted that additional amide peaks occur as one of the first changes. Another notable change occurring in the stent is appearance of carboxylic acid peaks. The changes in the amide and carboxylic acid peaks occurring over time can be thus explained as to be due to the proteins in the early biofilms formed on the stents.The changes at around 2349 cm -1 region denotes phosphines. Also there is evidence for P-H group occurring in the case of new stent. Phosphines are organophosphorus compounds with P-H bonds.

In the stents, silicon carbide is used as a coating agent. During the process, phosphine is used as a cracking agent (6). Phosphine compounds cause adverse effects in biological system according to existing evidences (7). Chronic inhalation of sub-toxic doses has been said to lead to anorexia and weight loss, anaemia, a tendency to spontaneous bone fracture, toothache, swollen jaw and mandibular necrosis. This can occur with absorption across body membranes. The absorption might occur across ureter and bladder muscosa also. But the carcinogenic effect of these compounds are not conclusively proved and they are not classified among carcinogens. In addition to these changes, disappearance of peaks as in the case of used stents at 1690 cm -1 points to changes occurring in the stent material. It is interesting to note that these changes occur as early as 6 weeks of indwelling time.

CONCLUSION:

With the commonly used biomaterial, the double J stents shows early tendency to form biofilms and encrustations. The appearance of carboxylic acid and amide peaks may denote proteins in the biofilms which facilitate the formation of encrustations. The material shows changes in its chemical structure as early as 6 weeks in-situ. Some of the chemical groups like phosphine are having proven significant adverse effects in the body. The adverse effects of stents in practice needs a more detailed examination. There is a need for better biomaterials to manufacture stents used in Urology.

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