The Effect of Extracorporeal Shock Wave Lithotripsy on Encrusted Memokath Stents

The human urinary system consists of two main passageways: the ureters, which allow the flow of urine from the kidneys to the bladder, and the urethra through which urine is excreted from the body (Tortora and Derrickson, 2006). Due to various urinary disorders, ranging from kidney stones and urinary strictures to prostate enlargement and cancer, these passageways become obstructed (Vanderbrink et al., 2008). Urinary tract obstruction increases the risk of infection, stone formation and can result in functional renal impairment or permanent renal atrophy (Thomas and Stanley, 2007).

Urinary stents are implanted both in the ureters and the urethra, to prevent and treat urinary tract obstruction (Vanderbrink et al., 2008). The early urological stents were mainly composed of non-metallic materials (Slepian and Yachia, 2004). The current standard stent is the non-metallic Double J stent, first introduced in the 1970s (Slepian and Yachia, 2004). In the recent years metallic stents, similar to those used in cardiology have been developed and are successfully used in clinical conditions (Slepian and Yachia, 2004). The Memokath (MK) stent is a nickel-titanium (Nitinol) wire coil stent, which exhibits thermal shape memory properties (Harboe and Nordling, 2004). When flushed with cold saline at approximately 10°C, the MK stent becomes ‘super soft’ and uncoils easily, thus permitting easy, non-traumatic removal (Harboe, 2004). However, stents have their own associated problems, mainly pain, risk of infection and encrustation (Vanderbrink et al., 2008). When a stent is in-situ, chemical constituents of urine combine with the surface of the stent and form a matrix on which waste products such as uric salts precipitate as calcified crystals (Vanderbrink et al., 2008). The end result is encrustation, which is a layer of crystal deposition on the stent that is mainly composed of calcium phosphate (Tunney et al., 1996). Encrustation can lead to further blockage of urine flow and increases the risk of infection (Gorman et al., 2003).

A large number of studies have attempted to encrust urological stents in an in vitro environment to conduct a range of investigations. Tunney et al (1996) used three different artificial encrustation models in order to produce encrustation in an in vitro environment that resembled that on in vivo stents. The same authors in 1997 used a different model in order to investigate the rate of encrustation on different stent materials (Tunney et al., 1997). Laaksovirta et al (2003) encrusted stents in vitro in order to compare the rate of encrustation on three different types of stents. Jones et al (2006) encrusted stents in an in vitro model to determine the effect of changing the artificial urine solution on the rate of encrustation. The most commonly used artificial urine solution composition is one that has been suggested by Cox et al (1987) and it has been reported that the addition of urease and calcium phosphate to the urine solution increases the rate of encrustation significantly (Tunney et al., 1996, Jones et al., 2006).

In literature, analysis is conducted primarily through scanning electron microscopy (SEM), electron dispersive spectroscopy (EDS) and compression strength testing. SEM has been used to quantify the amount of encrustation on stents in terms of the average thickness and coverage (Lai et al. 2007; Cauda F. et al. 2008). It is also used to investigate stent surface properties i.e. checking for defects and micro-pores (Cauda V. et al 2010). EDS is used for elemental analysis, essentially to check the composition and relative ratio of elements in encrustation (Cauda V. et al 2010). The compression strength of a stent is vital to its role in preventing duct collapse, and is usually measured by
compressing the stent specimen between two parallel planes at different intervals (Laaksovirta et al. 2003).

Current treatment for encrustation involves the removal or replacement of the encrusted stents, either cystoscopically (where a flexible narrow tube is inserted through the urethra and the stent is pulled out) or through open surgery (Leveillee, 2004). While open surgery is massively invasive, troublesome and costly, cystoscopy carries the risk of damage to the urethra and stent fracture if the stent carries large amounts of encrustation (Leveillee, 2004; Watterson et al., 2004). Therefore the removal of encrustation prior to replacement of the stent is desirable. The stent replacement rates of Double J and Memokath stents differ dramatically, with MK being replaced every 12-18 months (Soni et al., 1994) and the Double J every 4-6 months (Wetton and Gedroyc, 1995). Hence the quality of life factor is considered to be better for the MK stent.

Extracorporeal Shock Wave Lithotripsy (ESWL) is a technique that is used clinically to treat kidney stones non-invasively by focusing high energy shockwaves on to the stone and disintegrating them into pieces small enough to be passed through the ureters (Lam et al., 2002). Despite the use of high energy shockwaves, ESWL is a relatively safe method for use in the body as the focus of the energy is directed upon a small elliptical area. ESWL has been used clinically to remove the bulk of calcified stone from heavily encrusted stents to ensure safe and easy removal (Leveillee, 2004; Watterson et al., 2004). Cass et al in 1993 reported six cases where ESWL was used to successfully remove encrustation from double J stents that would have otherwise required open surgery. In 2010 Pricop et al used 3000 shocks on an encrusted double J stent to remove encrustation with no damage to the stent. Furthermore Buchholz et al (2005) used ESWL on zebra stents and found that the zebra stent – featuring Ni-Ti metal core and a Teflon coating - was resistant to the effects of ESWL used at clinical levels, even on parts of the stent thought to be most prone to damage. However the use of ESWL on the Memokath stent, which is a relatively new design, is scarcely reported in literature. Since MK stents are capable of resisting encrustation for longer periods than conventional double J stents, using ESWL on MK stents safely to remove encrustation in-situ could further increase the longevity of the stent, thus providing a better quality of life for patients and reducing the cost of frequent surgery for the NHS.

This project is run in collaboration with Mr. Noor Buchholz (consultant urological surgeon, Barts, London) and PNN Medical, Denmark, which produces the Memokath stent, and aims to investigate the effect of ESWL on encrusted Memokath stents, in terms of the removal of encrustation, the effect on the properties of the Memokath stent and any adverse effects on surrounding tissue.

An accelerated encrustation model and an artificial urine solution will be chosen based on existing literature to encrust stents rapidly, within a period of 8 weeks at most. EDS and SEM imaging will be used to evaluate and quantify the encrustation prior to the use of ESWL. Next, an ESWL model will be designed that allows the safe and physiologically acceptable application of shockwaves on the stent. The model will incorporate means of assessing temperature changes and vibrations of the stent during the application of ESWL in order to evaluate possible surrounding tissue damage. Further SEM analysis will be conducted on the stent post ESWL in order to determine if the encrustation has been successfully removed and if the surface properties of the stents have been altered. Compressive strength testing will also be carried out on the stents to assess its mechanical properties. Finally, the ESWL treated stents will be re-encrusted in the model to determine if the rate of encrustation has increased after the application of ESWL.

References


