How to manage encrustation and blockage of Foley catheters

Long-term catheterisation is rarely completely free of complications. Encrustation by mineral salts, leading to catheter blockage, is a common problem for 40–50 per cent of patients with long-term catheters (Kohler-Ockmore and Feneley, 1996; Getliffe, 1994).

The recently published paper Control of encrustation and blockage of Foley catheters (Stickler et al, 2003) is a welcome addition to the relatively small evidence base available to guide the care of patients with long-term, indwelling catheters.

The laboratory-based study conducted by Stickler et al (2003) used a model of the catheterised bladder and clearly demonstrates that filling the catheter balloon with an antimicrobial agent can inhibit the colonisation of the catheter by micro-organisms, which contribute to encrustation formation.

Reasons that encrustation of catheters occurs

The major components of catheter encrustations are struvite (magnesium ammonium phosphate) and calcium phosphate, which precipitate from the urine under alkaline conditions (Cox and Hukins, 1989). Such conditions occur when the catheter surface is colonised by micro-organisms that are capable of producing the enzyme urease.

One of the most common and potent producers of urease is Proteus mirabilis, which is often present in the patient’s own bowel flora. Other micro-organisms, including Providencia species and Morganella species, also produce this enzyme. Urease catalyses the breakdown of urinary urea to release ammonia.

Ammonia in solution is alkaline, resulting in an increase in urine pH. As micro-organisms colonise a catheter surface, they rapidly multiply, forming a living layer of biofilm communities embedded in a polysaccharide matrix produced by their secretions (Costerton et al, 1999). Crystals deposited from the urine become trapped in the organic matrix and can eventually block the catheter.

Recurrent catheter blockage

Recurrent catheter blockage is distressing to patients and carers, and costly to health services in terms of time and resources.

The length of time the catheter remains patent in patients who experience recurrent blockage varies from person to person. It can range from a matter of days in very severe cases, to weeks in others (Getliffe, 1994).

In clinical practice, current care strategies are aimed at managing the problem through a policy of planned catheter changes based on individual patients’ patterns of blockage. In addition, catheter washouts with acidic catheter maintenance solutions (which are used to dissolve encrusted material) can be used to prolong the period that the catheter remains patent.

However, although all catheters are susceptible to this problem, there are no effective procedures for preventing it (Morris et al, 1997). Previous laboratory studies suggest that any attempt to reduce urinary pH to prevent catheter encrustation, without the elimination of urease-producing micro-organisms, is unlikely to be successful (Bibby et al, 1995).

Using an antimicrobial in the catheter balloon

The study by Stickler et al (2003) provides the first evidence of the potential benefits of filling the catheter balloon with the antimicrobial agent, triclosan, instead of water, in order to prevent or reduce encrustation of the catheter.

Triclosan is used in soaps, surgical scrubs, deodorants, toothpaste and mouthwashes. It was selected for study because previous work had shown that Proteus mirabilis isolated from encrusted catheters was extremely sensitive to it (Stickler, 2002).

Stickler et al (2003) report the results of two sets of experiments using a model of the catheterised bladder, which consisted of a glass chamber (or chambers) maintained at 37°C by a water jacket.

A size 14 all-silicone catheter was inserted into the base of the chamber, and artificial urine was pumped through the chamber at 0.5 ml/min. Conditions conducive to the formation of a urease-producing biofilm, which would lead to catheter encrustation, were created by infecting the urine with a culture of Proteus mirabilis (isolated from a catheterised patient).

Diffusion of triclosan into urine from the catheter balloon

The first set of experiments was designed to test the ability of triclosan to diffuse through the catheter balloon into urine. The time taken for a test catheter with a balloon filled with 10ml of triclosan (10g/l in 5 per cent weight/volume polyethylene glycol) to become blocked was compared with the time taken for a control catheter with a water-filled balloon to become blocked.

Scanning electron microscopy (SEM) was used to visualise biofilm colonisation or encrustation. The results of four replica experiments showed that control catheters became blocked in a mean time of 24 hours and 15 minutes. The pH rose from 6.1 (acidic) to 8.6 (alkaline) during this time.

By contrast, test catheters inflated with triclosan were
still draining freely after seven days and the urine remained acidic (pH 6.7). SEM on sections of catheter in the experimental group showed little evidence of biofilm formation or encrustation.

Impregnation of triclosan throughout the length of the catheter. In a second series of experiments, the researchers were able to demonstrate that triclosan became impregnated throughout the length of the catheter and inhibited biofilm formation. Catheter balloons were inflated with triclosan, inserted into the model of the catheterised bladder and supplied with sterile urine for 24 hours.

The catheter balloons were then deflated, washed thoroughly with water and reinflated with water. These test catheters were then infected via the same method used in the first experiment. The time taken for blockage to occur was compared with the time taken by the control catheters.

The results of three replica experiments showed that the mean time to blockage for control catheters was 29 hours and the pH rose to 8.4 (alkaline). Catheters that had initially been inflated with triclosan and then washed out with water drained freely for seven days, with the pH remaining acidic at 6.2.

SEM of catheter cross-sections from the experimental group revealed little evidence of biofilm formation. When 1 cm sections of test catheters were incubated overnight on agar plates, which had been inoculated with Proteus mirabilis, large zones of bacterial inhibition around the catheter sections were produced. This demonstrated the presence of a source of antimicrobial agent, located within the catheter material. Sections from control catheters produced no such zones.

Discussion These early results, based on laboratory work, clearly look promising in addressing the problem of catheter encrustation and blocking. However, there are further interesting questions to pursue, as well as limitations to be recognised in relation to how closely any laboratory model can simulate the clinical situation.

The use of artificial urine in a laboratory study allows the researchers to control the urine composition, and therefore the impact of any potential inhibitor or promoter of the encrustation process. However, it is unclear if any organic material was included in the recipe used in this study.

Previous work has shown that early deposition of proteins or lipid material on catheters in clinical use is likely to rapidly mask specialist surface properties, rendering them less effective in the longer term (Ohkawa et al, 1990).

The catheters that were inflated with triclosan remained free-flowing for at least seven days, which would be of clinical benefit to many patients. However, it will be important to test the longer-term effects of this treatment (in laboratory and clinical settings) because many patients with recurrent blockage problems retain their catheters for several weeks before blocking.

In this study, the model simulated heavy infection with a pure culture of Proteus mirabilis. This micro-organism is a potent producer of urease and is frequently present in the urine of patients who experience recurrent catheter blockage. However, catheter biofilms are commonly mixed communities of two or more different micro-organisms.

It will be interesting to see if triclosan (or other antimicrobial agents) are effective against such mixed communities or if inhibition of one member – for example, Proteus mirabilis – may permit colonisation and dominance by others.

Bibby et al (1995) first suggested that to control catheter encrustation the inflation balloon should be filled with an antimicrobial solution rather than water. Previous studies have shown that low concentrations of mandelic acid will diffuse through the balloon.

Triclosan is sparingly soluble in water but is freely soluble in silicone and organic solvents such as polyethylene glycol. This property undoubtedly contributes to its successful impregnation throughout the length of the all-silicone catheter, but is an effect which may not occur with other catheter materials or with other water-soluble antimicrobial agents.

Conclusion The method used by Stickler et al (2003) has much to recommend it. Inflation of the catheter balloon with an antimicrobial agent does not create any break in the closed drainage system, and the technique could be used for delivery of other agents directly to the bladder, including antibiotics for treatment of catheter-associated urinary tract infections.

The use of a model to test out new ideas is common and allows researchers to examine the impact of one or more interventions while controlling other conditions that might influence the results. It would be unethical to test new techniques on patients without undertaking thorough preliminary work.

The next stage must be to rigorously test the effectiveness of balloon inflation with triclosan in the clinical situation, before practitioners can begin to adopt this approach. ■

REFERENCES


