

Advances in Urinary Catheter Technology

Robyn J S Webber

Introduction

The first recorded use of a urethral catheter was in ancient Egypt, when papyrus reeds were used to artificially drain the bladder. Subsequently, a variety of other materials, including metals (bronze, copper, silver and tin), and animal skins were used to produce primitive catheters. The first rubber catheters were produced in the 1800s, initially without, and later with, the provision of a balloon to aid in retaining the catheter in the bladder. Today, urinary catheters can be made from a number of materials, including latex, PVC and silicone. They are specifically designed for different uses; short and long-term indwelling catheters, and for intermittent self-catheterisation.

There are a number of practical problems associated with urinary catheter use. These include discomfort and trauma on insertion, and the risks of urinary tract infection and catheter encrustation. Clearly, the degree of relevance of each of these issues varies with the situation in which the catheter is being used, but in all cases there has been considerable research into developing catheter technologies to combat each specific potential complication. This article summarises some of the difficulties encountered in the past, and examines some of the emerging technologies for dealing with catheter-related problems.

Biocompatibility

Modern urinary tract catheters are largely well tolerated, and this may almost be taken for granted. However, this was not always the case. Whilst, not surprisingly, early catheters may not have been particularly comfortable or compatible with human tissues, biocompatibility has really only been addressed in recent years. It was during the 1980s that it was first recognised that biocompatibility was an important issue to consider, and at that time many cases of severe damage to the urethra following catheterisation with a latex catheter were reported. Interestingly, the cause in most instances was not actually latex, but a reaction to substances added to the latex at the time the catheter was manufactured.¹ Following this discovery, the testing of new urinary catheters for biocompatibility assumed a new importance, and is now mandatory. A variety of tests may be performed to assess biocompatibility, including *in vivo* animal studies, and experiments involving the exposure of proposed new catheter materials to cultures of human urothelial cells.²

Biofilms and encrustation

For indwelling catheters, be they urethral or suprapubic, encrustation may prove a significant problem. Encrustation is a complex process, in which crystalloid and colloid sub-

stances adhere to the surface of the catheter.³ It has been the focus of considerable study. Encrustation may happen whether the urine present is infected or sterile, and is thought to involve a number of steps, commencing with the adsorption of urinary proteins onto the surface of the catheter, with subsequent formation of a biofilm to which other materials, eg. bacteria, may adhere. A significant proportion of the studies with respect to encrustation and biofilm formation have been performed with ureteric stents, but some of their findings may also be applied to the development and use of long-term urinary catheters. It has been suggested that the actual protein content of biofilms may vary between encrusted and nonencrusted stents;⁴ a finding that could well be extrapolated to urinary catheters, and may be of practical use in the search to find ways of reducing or entirely preventing encrustation from occurring. Once biofilm formation has commenced, the process currently is not able to be reversed, and if bacteria are present, and adherent to the catheter, the biofilm may protect the organism from the effect of antibiotic agents.⁵ Encrustation may also occur in sterile urine, and frequently these encrustations consist of calcium oxalate crystals. This process is less well understood than encrustation in the presence of infection. In an attempt to avoid the development of encrustation, various measures have been tried, including the use of long-acting antimicrobial coatings, and treatments designed to detach biofilms as they form. Currently however, these measures are far from perfected, and encrustation will remain a significant problem for indwelling catheters for the foreseeable future.

Issues in intermittent self-catheterisation

The establishment of intermittent self-catheterisation (ISC) as having a vital role in the management of a variety of bladder disorders, has brought its own unique set of practical problems. Clearly encrustation is not an issue, but as with longer-term catheters, those for intermittent use must be inert and comfortable for the patient, as well as being safe, easy to use, and with minimal risk of promoting infection. Previously PVC catheters (with an additional lubricating agent) were used for ISC, and are still used by some patients. A number of complications have been recognised associated with their use, including an allergy to the lubricant, and the development of urethral strictures and false passages in men; the incidence of which has been reported to increase with length of use.⁶

The introduction of single use, hydrophilic coated catheters for ISC has meant that PVC



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catheters have been largely (but not entirely) superceded. These catheters are supplied with a coating, which, when wetted prior to insertion in the urethra has a low coefficient of friction (ie. is very slippery), making such catheters easier and more comfortable for patients to insert. Studies have suggested that with the use of these catheters over traditional PVC catheters, the incidence of urethral strictures and false passages is reduced.⁶ These catheters are recommended for single use as the hydrophilic coating (and therefore the degree of lubricity) wears away with repeated use. In addition, it has been shown that these catheters should not be left inserted in the urethra for prolonged periods (particularly in men), as they can become sticky. In this situation, force may be required to remove the catheter from the urethra, causing urethral trauma.⁷

Coatings for urinary catheters

It is vital to ensure the smooth passage of any urinary catheter, and this is especially important with those catheters used for ISC. Again it is important to reduce the risk of infection associated with catheter use to a minimum. Hence, there has been interest in the development of antimicrobial coatings for use with both intermittent and indwelling urinary catheters. An ideal situation may be to have a combined hydrophilic and antimicrobial coating, and such agents are now under development. One such a coating is LubriLAST™ (AST

Products Inc); a hydrophilic coating, which can be used alone, or can be linked with an antimicrobial coating. The antimicrobial coating is designed to gradually release antimicrobial agents when in contact with bodily fluids. This can be customised, so that the rate at which these agents are released can be varied, so there can be an initial release, followed by a slower, more controlled release of the antimicrobial agent. The ability to vary this rate means that the antimicrobial properties may be altered, depending on whether the catheter is for long-term or intermittent use. As catheters with these coatings become more freely available, it will be interesting to see not only whether rates of catheter associated infection are reduced, but also, for long-term catheters, where there may be any reduction in the rate of encrustation.

Summary

The development of catheters for the urinary tract has become a highly technical exercise, with the aim of producing catheters that are easy to use for patient and health professional alike, with a low associated rate of infection, and minimal encrustation rate. Arguably, encrustation remains the greatest problem yet to be solved satisfactorily. In general though, advances such as the development of hydrophilic and antimicrobial coatings have meant that catheterisation, especially for those patients practising ISC is, with appropriate training, safe and atraumatic.

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Indications: Treatment of erectile dysfunction. To be effective, sexual stimulation is required. Not for use by women. **Dosage:** *Adult men:* 10mg approximately 25 to 60 minutes before sexual activity. Based on efficacy and tolerability the dose may be increased to 20mg or decreased to 5mg.

The maximum recommended dose is 20mg once per day. Can be taken with or without food, onset of activity may be delayed if taken with a high fat meal. *Elderly men:* A first dose of 5mg should be used. *Mild and moderate hepatic impairment, severe renal impairment:* A starting dose of 5mg should be considered. *With other medicinal products:* In combination with erythromycin, the dose of vardenafil should not exceed 5mg.

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