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Clinical and cost effectiveness of urethral catheterisation: a review

by Bevan Michael Scott

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Reducing the number of catheter-associated urinary tract infections (CAUTI) in the National Health Service (NHS) has the potential for large cost savings. This review identifies factors which affect the incidence rate of CAUTI, as well as the need for further studies investigating cost-effectiveness, particularly in the areas of silver alloy catheters and education.

Introduction

The cost of treating hospital-acquired infection (HAI) may be as much as one billion pounds per year, and around 15% of these infections could potentially be prevented, saving the National Health Service (NHS) £150 million per year (National Audit Office [NAO] 2000). These are the findings in a report published by the National Audit Office in February 2000, which investigated the strategic management of HAI, and how well they are controlled through prevention, detection and containment measures within NHS hospital trusts in England.

A further progress report published in 2004 by the National Audit Office, which considered improving patient care and reducing the risks of HAI, concluded that the NHS still lacks sufficient information with regard to the extent and cost of HAI. In the same year, Brosnahan et al (2004) suggested that urinary tract infections (UTIs) are the most common hospital acquired infection. A recent randomised controlled trial has shown that catheterised patients have an increased risk of acquiring a UTI (Djaladat et al 2007). The Department of Health Winning Ways publication (2003) identified urinary infections as the most common healthcare associated infection. Winnings Ways quoted a national prevalence survey published in 1996 by Emmerson et al, suggesting that 23% of infections in hospitals are urinary infections. Niel-Weise and Van den Broek (2005)

suggest that approximately 40% of hospital-acquired infections are UTIs and that 80% of these are caused by urethral catheters. Reducing the number of catheter-associated urinary tract infections (CAUTI) in the NHS has the potential for large cost savings.

Objective

This review will consider the cost and clinical effectiveness of urethral catheterisation. The author acknowledges the vast quantity of literature already published in regard to the subject, and therefore this review will concentrate primarily on CAUTIs. Factors affecting the rate of CAUTIs will be identified. The aim of the review is to establish areas in need of further research. A better understanding of the factors that lead to CAUTI may lead to a better understanding of how to reduce costs and increase clinical effectiveness.

Literature criteria

Randomised, quasi-randomised trials, systematic reviews and audits were identified which investigated the incidence of CAUTI. The following databases and search engines were searched as a source of literature for inclusion in this review: Cochrane Database, CINAHL, Pubmed, Medline, Proquest, Internurse & Blackwell Synergy.

Duration

The Royal College of Nurses (RCN) has produced guidance on catheter care in order to provide a framework for standards and quality care in this area (RCN 2008). The RCN comprehensively covers many aspects of catheter care and discusses infection risks associated with catheters in situ for longer than 48 hours. Several trials have noted a relationship between the duration that catheters are kept in situ and the risk of acquiring an infection (Corina et al 2003, Hakvoort et al 2004, Huang et al 2004, Topal et al 2005, Apisarnthanarak et al 2007, Crouzet et al 2007).

Two recent Cochrane Systematic Reviews (Griffiths & Fernandez 2007, Phipps et al 2006) both considered the effects of early removal of urethral catheters on the risk of infection. Phipps et al (2006) suggested in their results that fewer UTIs were likely in patients who had their catheters removed within three days of insertion. Griffiths and Fernandez (2007) concluded that a lower risk of infection was associated with early removal of catheters.

Nine studies (Corina et al 2003, Dunn et al 2003, Hakvoort et al 2004, Huang et al 2004, Lee et al 2004, Topal et al 2005, Apisarnthanarak et al 2007, Crouzet et al 2007, Kamilya et al 2010) tested the relationship between the duration of the catheter in-situ and the rate of CAUTI, either as a primary or secondary objective. Seven of the trials (Corina et al 2003, Hakvoort et

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al 2004, Huang et al 2004, Topal et al 2005, Apisarnthanarak et al 2007, Crouzet et al 2007, Kamilya et al 2010) found a decrease in the rate of CAUTIs during a shorter period of catheterisation.

Hakvoort et al (2004) randomised controlled trial quotes a tenfold reduction in CAUTIs when comparing the results of short-term (24 hour) catheterisation, with long-term (5 day) catheterisation. The trial compared long and short-term catheterisation following vaginal prolapse surgery. The experimental group had the catheter removed the day after surgery, and the control group on the fifth postoperative day. This provided a durational difference of four days and resulted in a mean additional hospital stay of 1.3 days for the control group. Hakvoort defined a UTI as a presence of >105 colony forming units/mL in a urine culture. This led to diagnosing 18 CAUTIs in the control group and two CAUTIs in the experimental group.

Kamilya et al (2010) recently conducted a very similar trial to that of Hakvoort. On this occasion Kamilya et al reduced the durational difference from four days to three days. This was achieved by creating two study groups. Group one had their catheter removed on the 1st post operative day and group two had their catheter removed on the 4th post operative day. The study found that participants of group one had a lower chance of developing a UTI.

Dunn et al's (2003) randomised controlled trial showed that early removal had no effect on the rate of CAUTIs. This study provided a durational difference of just 24 hours. The very small difference in the duration of the catheter being left in-situ, may explain why there was no statistical difference in the results. This study does suggest however, that immediate removal could shorten hospital stay. This is due to no reason being found for the catheter to remain in for a longer period of time.

Both Dunn et al (2003) and Hakvoort et al (2004) tested the effect of duration on the rate of CAUTIs, but tested different duration lengths. Both had different criteria for defining a UTI. Hakvoort et al (2004) defined a UTI as a presence of >105 colony forming units/mL in a urine culture. Three

other studies (Huang et al 2004, Topal et al 2005, Crouzet et al 2007) used the same criteria for defining a UTI. Dunn et al (2003) proposed no clear definition of a UTI, neither did Corina et al (2003) or Apisarnthanarak et al (2007). Lee et al (2004) defined a UTI as a presence of >103 colony forming units/mL in a urine culture. As a result, comparing statistical results of these trials is complex. The literature reviewed however suggests that early removal of urethral catheters lowers the rate of CAUTIs. Lee et al's (2004) study was the only study to show a decrease in the rate of CAUTIs during prolonged catheterisation (5-7 days). The fact that the two groups of the study were based in different hospitals, contained very small sample sizes, and produced results that were statistically insignificant, may explain their findings.

Removal reminders

Of the eight studies reviewed, seven (Corina et al 2003, Dunn et al 2003, Hakvoort et al 2004, Huang et al 2004, Lee et al 2004, Topal et al 2005, Crouzet et al 2007) involved either a trial investigating reminders to doctors to remove catheters or a trial design including a scheduled removal. All seven trials suggest that removal reminders do affect the rates CAUTIs. Corina et al (2003) investigated the effect of a computer-based removal reminder system and found that, as a result, the number of catheter days had decreased. The study also showed a decrease in CAUTIs. The study was not able to prove that the decrease in CAUTIs was a result of the removal reminders, as the study's primary objective was to measure duration.

In 2008 Fakhri et al conducted a nurse-led multidisciplinary team evaluation of the need for urinary catheters in patients on medical and surgical wards. Unfortunately this study did not look at duration versus rate of CAUTIs. The study utilised the Centre for Disease Control and Prevention's recommendations for urethral catheterisation. These recommendations were considered on ward rounds by the multidisciplinary team. A request was then made to doctors to authorise the removal of catheters that were no longer considered

necessary under these recommendations. The rate of discontinuation of unnecessary urethral catheters was found to be 45%. Areas for further research may include a qualitative study into staff attitude and perceptions of removal reminders, as well as Fakhri et al repeating their study to include consideration of the removal reminders on CAUTIs.

Silver alloy catheters

A recent audit (Seymour 2006) of CAUTIs using silver alloy-coated catheters has been undertaken. The aim of the audit was to evaluate the reduction in the rate of CAUTIs using a time-sequenced non-randomised intervention study. The rate of CAUTIs during a baseline period using the trust's standard catheters was compared with an evaluation period using silver alloy catheters. The audit quotes a reduction in the risk rate of developing a CAUTI of 72% when using silver alloy catheters, but fails to define the risks, or how this figure was calculated. The primary objective, to evaluate the reduction of CAUTI, was measured as CAUTI/1000 catheter days. This is a standard format for presenting data concerning the rate of CAUTI. The rate of reduction of CAUTI was 69.9%, which exceeded the authors' estimate of 20%. The audit failed to identify the catheter used in the baseline period and used a very small sample.

Five literature reviews (Niel-Weise et al 2002, Brosnahan et al 2004, Davenport & Keeley 2005, Johnson et al 2006, Phipps et al 2006) discuss silver alloy catheters. A literature review published in 2002 (Niel-Weise et al 2002) sought to evaluate the effectiveness of silver alloy catheters in preventing CAUTI in comparison with uncoated catheters. Despite the high quality of the review, only a low number of trials were identified and these were of poor quality. As a result insufficient evidence was found and the review was unable to recommend the use of silver alloy catheters.

Following Niel-Weise et al (2002), Brosnahan et al's (2004) systematic review concluded that silver alloy catheters prevent CAUTIs in short-term catheterised patients. Davenport and Keeley's (2005) review supports the conclusions of Brosnahan et al (2004). However, Davenport and Keeley →

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quote a reduction rate of CAUTIs of 45% (Lai & Fontecchio 2002) but fail to mention that the statistics of the study quoted (Lai & Fontecchio 2002) were found to be insignificant.

Phipps et al (2006) reviewed a small number of poor quality trials and was unable to draw any conclusions from the literature reviewed. Johnson et al's (2006) systematic review of antimicrobial catheters noticed that the results of recent trials investigating the reduction of CAUTI when utilising silver alloy catheters, showed silver alloy catheters to have a diminished effect in reducing CAUTI's in comparison to the results of earlier trials. Johnson et al (2006) suggested that this could be due to recent improvements in aseptic technique, methods and hand washing, but presented no evidence to support these suggestions. Johnson et al (2006) found considerable evidence to suggest that antimicrobial catheters, including silver alloy catheters, are effective in delaying the onset of bacteria in short term catheterised patients.

Seven studies (Bologna et al 1999, Saint et al 2000, Plowman et al 2001, Newton et al 2002, Lai & Fontecchio 2002, Rupp et al 2004, Srinivasan et al 2006) of various designs consider the effect that silver alloy catheters have on the rate of CAUTIs. Six studies (Bologna et al 1999, Saint et al 2000, Plowman et al 2001, Lai & Fontecchio 2002, Newton et al 2002, Rupp et al 2004) showed a decrease in the rate of CAUTIs when utilising silver alloy catheters. However Plowman et al (2001) and Saint et al (2000) utilise a model design based on estimates, and as such do not present true results. The primary objective of both studies is to assess the potential cost benefits of silver alloy catheters and, as a result, base cost calculations on previous study results regarding reduction rates of CAUTIs.

The remaining four studies (Bologna et al 1999, Lai & Fontecchio 2002, Newton et al 2002, Rupp et al 2004) are non-randomised cohort studies. Bologna et al (1999), Newton et al (2002) and Rupp et al (2004) all quote incidence rates of CAUTIs per 1000 catheter days. Interestingly Lai and Fontecchio (2002) quote incidence of CAUTIs per 1000 patient days, making the

results of their study not comparable with the other three studies. Lai and Fontecchio's (2002) reduced rate of CAUTI, of 45%, also proved to be statistically insignificant, raising questions about the study design and the decision to use historical data on CAUTI as the control group data.

The remaining study (Srinivasan et al 2006) failed to show any significant reduction in the rate of CAUTIs despite considering the rate of CAUTI per 1000 catheter days. Despite the sample size of 3036 patients this study was limited by gender differences in the study groups and by some patients being on continuous antibiotics, which may have affected the results.

Many of these studies are not comparable, due to study design and CAUTI rate definition. Some of the studies provide evidence to suggest that silver alloy catheters reduce CAUTI, however caution is needed when interpreting this evidence. Some recent studies (Srinivasan et al 2006), although possibly considered unreliable, have shown silver alloy catheters to be ineffective in reducing the rate of CAUTIs.

Antibiotics

One randomised controlled trial (Wazait et al 2004) investigated the effect of prophylactic antibiotics use on the rate of CAUTI. In this randomized double-blind placebo-controlled trial, patients were randomly allocated to either the placebo group or the second group receiving prophylactic ciprofloxacin. The study found no detectable significant benefit in using prophylactic ciprofloxacin to reduce the urinary tract infection rate after catheter removal. Unfortunately the study utilised an extremely small sample size of just 48 patients and one limitation of this study is that it is unable to rule out the occurrence of the urinary tract infection resulting from the efficiency of bladder emptying after catheter removal.

Recently Taiwo and Aderounmu (2006) investigated the susceptibility of UTIs to various antimicrobial agents. They found that over a period of five years, some pathogens found in CAUTIs had become

resistant to various antibiotics. The authors called for a reassessment of the rationale for prophylactic antibiotic use after catheterisation. The study also identified the antibiotic nitrofurantoin as being effective in reducing pathogens in CAUTIs.

Wazait et al (2003) analysed catheter samples of urine, over a five-year period, and found nitrofurantoin to be one of the most effective antibiotic agents in managing CAUTIs. Nitrofurazone, an antimicrobial agent similar in structure to nitrofurantoin, is currently used to coat urinary catheters. Lee et al (2004) conducted a non-randomised controlled trial and compared the effects of nitrofurazone-coated antimicrobial catheters with silicone catheters on the incidence rate of CAUTIs. Unfortunately the trial design utilised a control group based in South Korea, and an experimental group based in the United States of America. This geographical distance may have contributed to communication difficulties and resulted in possible inconsistencies within the trial. The experimental group did show a lower incidence rate of CAUTIs in comparison to the control group, using silicone catheters. However the results of the trial were found to be statistically insignificant for CAUTI developing between 1–4 days. The results for CAUTIs developing after 5 days of catheterisation and up to 7 days of catheterisation did prove to be statistically significant. The incidence rate of CAUTIs in the nitrofurazone-coated catheter group was lower, suggesting that prophylactic use of antimicrobial catheters could potentially lower the rate of CAUTIs in some patient groups. Another limitation of this study is that it was supported by a pharmaceutical company.

The evidence presented thus far is inconclusive. The studies discussed are generally of poor quality. Limited evidence was found in a Cochrane review (Niel-Weise et al 2005) to support the prophylactic use of antibiotics to reduce rates of CAUTI. This systematic review was concerned with antibiotic policies for short-term catheter bladder drainage in adults. It suggested that there was weak evidence to support prophylactic use of antibiotics up to 3 days post-operatively. Johnson et al's (2006) systematic review concluded that anti-

microbial urinary catheters could prevent or delay the onset of bacteria in some patient groups, however this depended on several variables, for example, catheter type. From the literature reviewed, it would appear that there is limited evidence to suggest that prophylactic use of antibiotics in catheterised patients may lower the incidence rates of CAUTI, however suitable patient groups would need to be considered as well as the costs involved.

Cost

Of the literature reviewed, fourteen studies (Bologna et al 1999, Plowman et al 2001, Lai & Fontecchio 2002, Newton et al 2002, Saint et al 2002, Tambyah et al 2002, Keerasuntonpong et al 2003, Brosnahan et al 2004, Huang et al 2004, Rupp et al 2004, Topal et al 2005, Seymour 2006, Srinivasan et al 2006, Apisarnthanara et al 2007) consider cost in relation to CAUTIs. These comprised one systematic review (Brosnahan et al 2004), one audit (Seymour 2006) and the remainder were trials of various designs.

The trials measure cost against one of the previously mentioned factors affecting the incidence rate of CAUTIs: for example Plowman et al's (2001) economic model to assess the cost and benefits of silver alloy coated urinary catheters. Unlike Plowman et al (2001), the majority of the trials report cost figures as a secondary objective. Type of catheter, duration of catheterisation and antibiotics are the factors most often linked with the costs of CAUTIs.

Topal et al's (2005) study of computerised feedback reported a decrease in CAUTI incidence of 47%, to which they attribute an estimated saving of \$234,000. This estimate was achieved by applying Tambyah et al's (2002) cost analysis, which is based on the organism causing the infection. Tambyah et al's (2002) study is the only study of its kind to investigate the costs of CAUTI based on the organism causing the infection. The costs calculated in this study took into account laboratory and medication charges, and additional length of hospital stay. The study reported an average cost of treating CAUTIs of \$539.

Apart from referencing Tambyah et al (2002) as the source of the cost saving analysis, Topal et al (2005) do not clearly explain how the figure of \$234,000 was achieved, possibly due to the cost analysis being a secondary objective of their study. However, so little information is presented concerning the estimated cost saving in Topal et al's (2005) study, that the validity of the estimates would be questionable. In Tambyah et al's (2002) study, a proportion of the \$539 average for treating CAUTI is attributed to length of hospital stay. The potential added length of hospital stay attributed to avoidable CAUTI was determined by an investigator. How this potential was calculated in the study is not clearly defined, raising more questions about future studies, similar to Topal et al (2005), who plan to base their cost saving estimates on previous studies.

A large portion of literature investigating costs savings of avoiding CAUTI has been concentrated on the type of catheter utilised. Six studies were identified in this review (Bologna et al 1999, Plowman et al 2001, Lai & Fontecchio 2002, Saint et al 2002, Rupp et al 2004, Srinivasan et al 2006). These studies are of varying quality, and only Saint et al (2000), Plowman et al (2001) and Rupp et al (2004) consider cost as a primary objective. Rupp et al's (2004) retrospective surveillance study utilised the cost estimate analysis of Tambyah et al (2002) and published cost estimate savings of between \$13,469 and \$535,452 for their study measuring the effect of silver alloy catheters. The study only took into account direct costs such as the cost of the catheters, which was obtained from hospital purchasing records. The cost saving estimates presented by this study are so wide ranging that it is difficult to understand their significance or what conclusions can be drawn from the results of the cost effectiveness analysis. It is clear from the study that silver alloy catheters offer cost savings, however what the study was not able to publish was the cost savings per use of silver alloy catheter. The literature reviewed suggests that a decrease in CAUTI rates leads to a decrease in length of hospital stay, resulting in lower costs. One survey (Mehta et al 2007), one trial

(Apisarnthanarak et al 2007) and one review (Griffiths & Fernandez 2007) reported a reduction in hospital stay in regard to the reduction of the rate of CAUTIs.

Education

The Royal College of Nursing has identified the need for 'Programmes of learning', particularly for health care assistants, in order to ensure that they acquire the appropriate knowledge, understanding and skills to deliver safe supervised catheter care (RCN 2008).

Two trials investigated the effect of education on the rates of CAUTIs. Topal et al (2005) tested three interventions simultaneously and therefore it is impossible to establish the effect of education. Rosenthal et al (2004) tested the effect of education and performance feedback on the rates of CAUTIs in intensive care units. The study shows that training and education of healthcare personnel can result in significant improvement in compliance with basic infection controls, which reduce the rate of CAUTI. However the study did not monitor any external factors as possible reasons for the decrease in CAUTIs, for example, administration of antibiotics. It is also possible that the results were affected by the Hawthorne effect. The National Audit Office (2004) concluded that further action was required to change staff behaviour in order to reduce the risks of hospital acquired infections, of which a large portion are CAUTI. A limited amount of literature was found concerning staff behaviour or the effect of education on CAUTIs, and no trials testing education, cost-effectiveness and CAUTI incidence rate could be identified.

Conclusion

This review has identified factors which affect the incidence rate of CAUTI and thus the clinical effectiveness of urethral catheters. Many of these clinical factors appear to have cost implications. Very few studies consider cost as a primary objective and further research is needed to establish which factors have the largest cost effects. An area for further research may include a ➔

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qualitative study into staff attitude and perceptions of removal reminders.

A large amount of research appears to be concentrated on the clinical effectiveness of silver alloy catheters. Unfortunately these studies are not matched by those investigating cost-effectiveness of silver alloy catheters. Further studies investigating cost-effectiveness, particularly in the areas of silver alloy catheters and education, may prove useful, should the £150 million burden that hospital acquired infections place on the NHS, ever hope to be reduced.

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