

# Indwelling Catheters With Bactiguard Silver Alloy Coating to Prevent Catheter-Associated Urinary Tract Infections in Patients With Spinal Cord Injury

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## Technology Overview

Bactiguard silver alloy coating is considered the key feature of the indwelling Bactiguard Infection Protection (BIP) Urinary Catheters, whose latex- or silicone-base models are used to promote bladder emptying and to maintain low-pressure voiding (Bactiguard SE, Stockholm, Sweden).<sup>1</sup>

Their proposed ability to reduce the incidence of catheter-associated urinary tract infections (CAUTI) in patients with or without spinal cord injury is presumed to result specifically from their coating with a silver alloy – including other noble metals (i.e., gold, palladium). The antimicrobial properties are intended to prevent the adhesion of bacteria to the inner surface of a catheter and thus preclude the formation of colonies of bacteria (biofilm) that can result in a CAUTI.<sup>2-4</sup> Silver's long-touted therapeutic potential has been attributed to the antimicrobial action of the silver ion (Ag<sup>+</sup>).<sup>5,6</sup> A hydrogel layer facilitates their placement.



The Bactiguard coating, which is applied to the catheter's inner and outer surface, is also available on a second product line (C.R. Bard, Inc., Covington GA):

- BARDEX I.C. anti-infective Foley catheter with Bactiguard silver alloy coating (latex);
- Lubri-Sil I.C. antimicrobial-coated silicone Foley catheter with Bactiguard silver alloy coating (latex-free); and
- BARDEX I.C. Complete Care infection control Foley catheter System with Bactiguard silver alloy coating and Bard hydrogel coating (latex).<sup>7-9</sup>

C.R. Bard purchases, then applies, the silver alloy coating to its own Foley catheters.

## Patient Group

Spinal cord injury is a high-cost health condition for the patient and the individuals, organisations, and health systems charged with caring for them.<sup>10</sup> Global incidence has been estimated at 23 traumatic spinal cord injury cases per million (as at 2007). This estimate includes land transportation, and water-related accidents and falls (especially in the elderly). Regional rates include: North America (40 per million), Western Europe (16 per million), and Australia (15 per million).<sup>11</sup> It has also been estimated that more than a quarter of a million American adults are living with a traumatic spinal cord injury, with approximately 10,000 new injuries occurring annually.<sup>12</sup>

Urinary tract infections constitute a large burden on the health and well-being of patients with spinal cord injury who experience some form of neurogenic lower urinary tract dysfunction, and especially for those who use indwelling urinary catheters to promote bladder emptying and maintain low-pressure voiding.<sup>3,4,13-15</sup> Urinary tract infections are the most common secondary medical complication of spinal cord injury during both acute care and medical rehabilitation.<sup>14,16,17</sup>

The various pathogenetic factors of neurogenic bladder dysfunction — such as bladder over-distention, vesicoureteral reflux, high-pressure voiding, large post-void residual volume, stones in the urinary tract, outlet obstruction — can compromise the effectiveness of processes that can prevent urinary tract infection.<sup>17</sup> Additionally, the mechanisms responsible for impaired bladder functioning are influenced by factors such as the time since injury, whether the injury is complete or incomplete, and the level of the injury.<sup>16</sup>

The risk of urinary tract infection in spinal cord-injured patients is enhanced by various factors, not least being the especially long-term use of indwelling urinary catheters. Placement of an indwelling urinary catheter provides an additional stable surface to which bacteria can attach and thereby avoid the natural host defenses of the urethral epithelium. For example, they can also serve as a conduit for the ascent of microbes into the bladder.<sup>2-4,17,18</sup> Other variables that increase the risk include:

- Being older than 40 years;
- Exhibiting poorer functional status;
- Having a complete spinal cord injury, as well as one that is at a higher (especially cervical) level; and
- Frequent exposure to antibiotics, which can increase the risk from antibiotic-resistant strains.<sup>14,19</sup>

The choice of catheter type depends greatly on the patient's current degree of dysfunction, morbidity and general functional status, and potential risks of adverse events (e.g. allergic reaction) and mortality.<sup>20-28</sup>

A current guideline reported an incidence of symptomatic urinary infection in male spinal cord-injured patients who chronically used standard indwelling catheters (not coated or impregnated with antimicrobials or antibiotics) to be 2.72/100 person-days.<sup>20,29</sup> By contrast, 0.41/100 and 0.36/100 person-days were the rates associated with intermittent (self) catheterisation and condom catheterisation, respectively. At the same time, using both clinical

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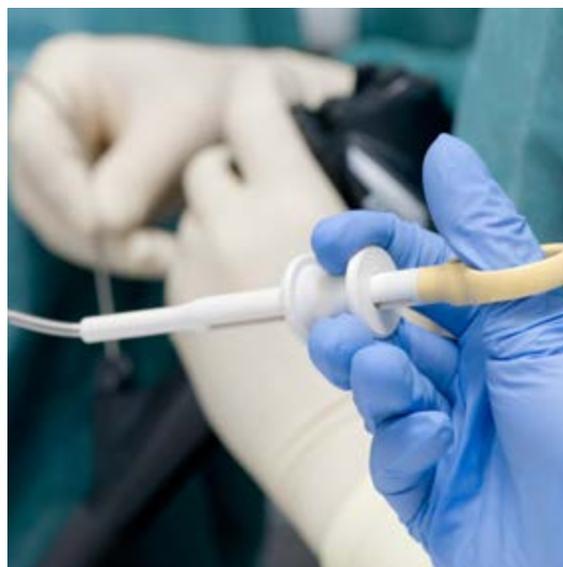
experience and the available evidence to guide their power calculation, investigators in the ongoing and pragmatic randomised trial of Bactiguard-coated catheters (the ESCALE trial) established a conservative estimate of 24.0% as the proportion of spinal cord-injured patients employing indwelling devices who would experience a symptomatic CAUTI.<sup>3</sup> This contrasts with an observed incidence of 12.6% in an in-patient population in the recently completed CATHETER trial.<sup>30,31</sup>

Even so, for various reasons the overall epidemiologic picture regarding CAUTI in spinal cord-injured patients who use these catheters has been considered unreliable. Observations have been obtained from dissimilar kinds of patients (exhibiting various risk factors) and via the use of different case definitions and other methodologies varying in terms of their rigour.<sup>12,20-23,29,32-34</sup>

## Potential for Impact

If, as compared with standard catheters, Bactiguard-coated ones can significantly reduce the incidence of CAUTI, then what might also be lessened are the frequency and the intensity of some of the common, increasingly serious instances of morbidity and related complications over the short-term and beyond. Additional complications may include:

- Discomfort;
- Psycho-emotional distress;
- Localised inflammation;
- Physical pain;
- Bacteremia and sepsis;
- Compromised daily functioning;
- Independence and opportunities to work; and
- Diminished quality of life.



The positive impacts of Bactiguard-coated catheters could in turn decrease the need to intervene to deal with these adverse effects (antibiotic use, and visits to, and potentially lengthy stays in, health facilities).<sup>2,18,34-37</sup> Improved bladder management strategies overall have helped make mortality less likely to follow events such as sepsis, renal failure, or a bloodstream infection.<sup>2,16,31,37-39</sup>

## Advantage Over Existing Care

The intended comparative advantage of Bactiguard-coated catheters in preventing CAUTI in spinal cord-injured patients is linked to the antimicrobial properties of its silver alloy.<sup>2</sup> Moreover, the prospect that they could perform effectively and safely for longer periods of time than is typically the case with standard indwelling devices could represent an additional advantage, considering that spinal cord-injured patients often require prolonged catheterisation.<sup>3</sup>

## Current Treatment Options

Current standards of care for use with spinal cord-injured patients and other populations include catheters manufactured from various materials. These include latex, silicone, a silicone-latex combination, polyvinyl chloride (or PVC), and polytetrafluoroethylene (or PTFE). These are employed for intermittent self-catheterisation or for use as indwelling devices; and although they can be pre-lubricated or may display other properties (hydrophilic, gel reservoir, sterile non-coated), none specifically include a presumed antimicrobial coating.<sup>12-15,20-23</sup>

As especially prolonged use of indwelling urinary catheters increases the risk of CAUTI, forms of intermittent self-catheterisation might be preferred.<sup>18</sup> Condom catheterisation is another option, as are suprapubic indwelling catheters, which require an initial surgical intervention.<sup>12,32</sup> Empirical evidence and expert opinion basically agree that the most effective way to prevent urinary tract infections may be to avoid using catheters; and, if required, to minimise the duration of their use.<sup>2,13-15,20-23,32,40-42</sup> However, this approach may apply only to a minority of spinal cord-injured patients.

## Clinical Effectiveness

No conclusive inference can be drawn in favour of or against the possibility of a short-term (less than 30 days) or long-term (30 days or more) comparative advantage in the effectiveness of indwelling Bactiguard-coated urinary catheters to prevent CAUTI in spinal cord-injured adult or older pediatric patients (acute or non-acute phase).

One registered, ongoing, open, multi-centre and single-blinded (outcome assessors) randomised trial (NCT01803919, ESCALE trial)<sup>43</sup> has aimed to examine prospectively and pragmatically the potentially long-term comparative benefits of Bactiguard-coated devices in preventing CAUTI in adult patients requiring at least seven days of catheterisation (n = 742). Each centre will use its own catheter management protocol, and the outcome assessments will take place at up to 30 days, or upon an earlier, clinician-determined removal, whichever comes first. The trial is estimated to be completed in 2015, with trialists recruiting individuals who will receive either the silicone model of the Bactiguard silver alloy-coated Infection Protection (BIP) Urinary Catheter or a standard indwelling one (most silicone or silicone-latex).<sup>3</sup> Interim analyses were not planned.

Also in this adult population, a case report has been published. It describes the use of an indwelling silver alloy-coated hydrogel catheter by a single 40-year-old male, who for 23 years had been using a latex indwelling device – changed monthly by his caregiver – to deal with the effects of sixth cervical level American Spinal Injury Association tetraplegia A.<sup>4</sup> During the six-month study, monthly changes permitted the physician to insert

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the silver alloy device, with the patient blinded to its identity. After having experienced monthly occurrences of symptomatic CAUTI that required the use of antibiotics in the six months prior to the intervention, no symptomatic CAUTI events were observed during the study. The patient's level of bacteriuria remained unaffected over this period of time; by study's end, with the bacterial flora having changed, only *Escherichia coli* (*E. coli*) was detected.

While other published clinical trial evidence exists – (with possible concerns as to its reliability because of limited or questionable methodologies such as the nearly universal use of asymptomatic bacteriuria as the primary outcome<sup>2,3,13-15,17,19-23,30-32,40-42,44-52</sup>) – the studies that have employed Bactiguard-coated catheters typically enrolled representatives from the general in-patient population (acute pathologies, elective surgery), and whose data cannot be meaningfully extrapolated to the spinal cord-injured patient population.<sup>2,3,8,20-22,30,31,40-42,45,48,53</sup> Reasons include the recognition that spinal cord-injured patients typically experience a distinctive clinical picture, which, in addition to difficulty voiding the bladder, can encompass a wide variety of types and intensities of signs, symptoms, challenges, and complications. These include:

- Problems emptying the bowel;
- Paralysis, spasticity, and pain;
- Fatigue, malaise, and lethargy;
- Psycho-emotional distress; and
- Difficulties with self-care.

Additionally, there is the need to intervene regularly to deal with these difficulties.

Yet, one of the biggest differences is that many spinal cord-injured patients need urinary catheterisation that lasts considerably longer, if not for life.<sup>2-4</sup> However, a recently updated Cochrane review of the available evidence obtained from in-patient populations suggests that silver alloy-coated urinary catheters may not provide a significant short-term comparative advantage in reducing the incidence of symptomatic CAUTI.<sup>54</sup>

## Safety

Regular testing of serum levels and urine revealed no evidence of silver toxicity in the single case study. The patient did not report having had any difficulty seeing at night, experiencing retching or wanting to vomit daily for three or more days, or having failed to have a bowel movement for one week on his current bowel program.<sup>4</sup> From controlled studies in populations other than spinal cord-injured patients, silver alloy-coated urinary catheters were well-tolerated (no toxic or allergic responses), and were as well-tolerated as standard indwelling ones or those impregnated with an antibiotic.<sup>30,31,40-42,48,53</sup> The possible adverse effects of silver alloy and antimicrobial resistance over the long-term in spinal cord-injured patients may be revealed by the ongoing ESCALE trial.

## Setting for the Technology Use

Some clinical settings in the United States and the United Kingdom, for example, currently employ Bactiguard-coated catheters.<sup>2</sup> As their management does not appear to require protocols that differ notably from those that are typically already in place in most contexts, it is probable that Bactiguard-coated catheters can be employed in any clinical practice setting in which other indwelling devices are currently being used with

spinal cord-injured patients. In the ongoing, multi-centre ESCALE trial, each facility could employ its in-house protocol.<sup>3,43</sup> The beneficial outcomes of Bactiguard-coated catheter use in any subgroup of spinal cord-injured patients depend on numerous facilitative factors (setting, training/experience, reliably practising to evidence-based standards, etc.) in addition to what the device itself can bring about.

## Regulatory Approval

Table 1: The Status of Bactiguard-Coated Catheter Approvals in Australia, North America, and the United Kingdom\*

	Bactiguard-Coated Devices	Australia	Canada	United States	United Kingdom
Regulatory Approval	Bactiguard SE	No approvals identified			
	C.R. Bard, Inc.	a. BARDEX I.C. Foley catheter with Bactiguard silver alloy technology (12/01/2009)	No approvals identified	a. BARDEX Lubri-Sil I.C. anti-infective all-silicone Foley catheter (12/07/2007) b. BARDEX I.C. pediatric Foley catheter (latex) (12/10/1999) c. BARDEX Lubri-Sil I.C. Foley catheter (latex) (02/16/1999) d. BARDEX I.C. four-way Foley catheter (latex) (11/03/1998)	No approval details could be found

\*As at July 8, 2014.

## Costs

On a per-unit basis, Bactiguard-coated urinary catheters are typically more expensive than most other options. This is especially the case for latex devices (AUS\$13.00 for a BARDEX male and AUS\$13.50 for a BARDEX I.C. female catheter), as compared to their latex counterparts from various companies (AUS\$2.50 to \$9.00). While per-unit prices do overlap somewhat when it comes to many silicone catheters (AUS\$12.00 to \$13.50 for a BARDEX Lubri-Sil device versus AUS\$5.10 to \$13.80), the cost of some devices from other companies (AUS\$14.95 to \$56.40) can exceed that of the Bactiguard-coated ones.<sup>55</sup>

Moreover, indirect costs of dealing with a spinal cord injury, especially when observed over the long-term such as the loss of productivity across the lifespan, may exceed direct medical and rehabilitation costs.<sup>3,10</sup> As the consequences and complications of CAUTI accrue, which include the need to intervene to address them, so do the financial burdens on those systems, organisations, and individuals responsible for providing care for these patients.<sup>37</sup> One estimate is that, without singling out any specific patient populations, CAUTI has cost the United

Kingdom's National Health Service £25million per year.<sup>56</sup>

Thus, to help justify their continuing utilisation, as well as their possible wider diffusion, the cost-effectiveness of Bactiguard-coated catheter use in the spinal cord-injured patient population needs to be determined.<sup>3</sup> Yet, what needs to be demonstrated first is a reliable and positive benefit-harms profile that is at least equivalent to what has been attributed to the current standards of care.<sup>30,31</sup> And, if it is discovered that Bactiguard-coated catheters are more likely to be kept in place in spinal cord-injured patients – CAUTI- and discomfort-free – for notably longer than might otherwise occur through the use of standard ones, their comparative advantage in delaying both the occurrence of CAUTI and the need to intervene professionally to address adverse effects (e.g., fewer catheter changes, antibiotics, readmissions, and lengthy hospital stays) could translate into an annual reduction in total spending.



This might begin to narrow the gap in cost that was defined initially by the difference in the catheters' per-unit price tags. However, the ability to detect such an advantage in delaying CAUTI for markedly longer periods of time in spinal cord-injured patients would require a definitive study that lasts long enough to observe one. It is debatable whether the ESCALE trial's assessment of the primary outcome up to 30 days post-catheterisation is long enough. The difference in patterns of longer-term use once again cautions against extrapolating cost-effectiveness data to spinal cord-injured patients from the studies of other patient populations.<sup>30,31,41,42,46,57</sup>

## Implementation Issues

The similarity of procedures to employ and manage catheterisation in spinal cord-injured patients using indwelling devices that are and are not Bactiguard-coated suggest that the current implementation of locally adopted protocols that aim to assure the reliable implementation of practices should suffice in guiding the reliable use of the former.<sup>12-15,20-23,58</sup> Add to this understanding the recognition that staff should already have been trained to implement these protocols and it is unlikely that any notable changes at the level of infrastructure or in the costs to bring them about would be required to allow the reliable use of Bactiguard-coated devices.<sup>3,43</sup>

## Report Limitations

Given the paucity of evidence, the possible comparative advantage of Bactiguard-coated catheters in either their clinical effects or cost-effectiveness in any subpopulation of spinal cord-injured patients (adult or pediatric; male or female; in-patient or outpatient) could not be ascertained.

## Report Methodology: Literature Search Strategy

A peer-reviewed literature search was conducted using the following bibliographic databases: PubMed, Embase,

EuroScan, and The Cochrane Library (2014, Issue 6). Grey literature was identified by searching relevant sections of the Grey Matters checklist (<http://www.cadth.ca/resources/grey-matters>). No filters were applied to limit the retrieval by study type. The search was limited to English language documents published between January 1, 2009 and July 8, 2014. Regular alerts were established to update the search until August 11, 2014.

## References

1. Bactiguard [Internet]. Stockholm, Sweden: Bactiguard AB. 2014 [cited 2014 Jul 29]. Available from: <http://www.bactiguard.se/>
2. Makuta G, Chrysafis M, Lam T. Measuring the efficacy of antimicrobial catheters. Nurs Times [Internet]. 2013 Nov 6 [cited 2014 Jul 9];109(44):16, 18-6, 19. Available from: <http://www.nursingtimes.net/Journals/2013/11/01/j/x/g/061113-Measuring-the-efficacy-of-antimicrobial-catheters.pdf>
3. Bonfill X, Rigau D, Jauregui-Abrisqueta ML, Barrera Chacon JM, Salvador de la BS, eman-Sanchez CM, et al. A randomized controlled trial to assess the efficacy and cost-effectiveness of urinary catheters with silver alloy coating in spinal cord injured patients: trial protocol. BMC Urol [Internet]. 2013 Jul 30 [cited 2014 Jul 11];13(1):38. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3735409>
4. Estores IM, Olsen D, Gomez-Marin O. Silver hydrogel urinary catheters: evaluation of safety and efficacy in single patient with chronic spinal cord injury. J Rehabil Res Dev. 2008;45(1):135-9.
5. Schierholz JM, Yucel N, Rump AF, Beuth J, Pulverer G. Antiinfective and encrustation-inhibiting materials--myth and facts. Int J Antimicrob Agents. 2002 Jun;19(6):511-6.
6. Fisher L. Development and evaluation of an antimicrobial urinary catheter [Internet]. Nottingham, UK: University of Nottingham; 2011. [cited 2014 Jul 29]. Available from: [http://etheses.nottingham.ac.uk/2222/1/Leanne\\_Fisher\\_Thesis.pdf](http://etheses.nottingham.ac.uk/2222/1/Leanne_Fisher_Thesis.pdf)
7. The Bard advantage in urological catheter systems [Internet]. Covington (GA): C.R.Bard, Inc.; 2004. [cited 2014 Jul 29]. Available from: [http://www.bardmedical.com/Resources/Products/Documents/Brochures/Urology/Foley\\_UrologicalCatheters\\_%200403\\_27.pdf](http://www.bardmedical.com/Resources/Products/Documents/Brochures/Urology/Foley_UrologicalCatheters_%200403_27.pdf)
8. Bactiguard [Internet]. Stockholm, Sweden: Bactiguard AB. A selection of publications of Bactiguard coated catheters; 2014 [cited 2014 Jul 29]. Available from: <http://www.bactiguard.se/about/the-solution-2/publications/>
9. Bactiguard [Internet]. Stockholm, Sweden: Bactiguard AB. A history of Bactiguard; 2014 [cited 2014 Jul 29]. Available from: <http://www.bactiguard.se/history/>
10. International perspectives on spinal cord injury [Internet]. Geneva: World Health Organization; 2013. [cited 2014 Jul 19]. Available from: [http://apps.who.int/iris/bitstream/10665/94190/1/9789241564663\\_eng.pdf?ua=1](http://apps.who.int/iris/bitstream/10665/94190/1/9789241564663_eng.pdf?ua=1)
11. Lee BB, Cripps RA, Fitzharris M, Wing PC. The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. Spinal Cord. 2014 Feb;52(2):110-6.
12. Consortium for Spinal Cord Medicine. Bladder management for adults with spinal cord injury: a clinical practice guideline for health-care providers. J Spinal Cord Med [Internet]. 2006 [cited 2014 Sep 15];29(5):527-73. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1949036>
13. Nicolle LE. Urinary tract infections in patients with spinal injuries. Curr Infect Dis Rep. 2014 Jan;16(1):390.
14. Nicolle LE. Urinary tract infections in special populations: diabetes, renal transplant, HIV infection, and spinal cord injury. Infect Dis Clin North Am. 2014 Mar;28(1):91-104.

15. Nicolle LE. Urinary catheter-associated infections. *Infect Dis Clin North Am*. 2012 Mar;26(1):13-27.
16. D'Hondt F, Everaert K. Urinary tract infections in patients with spinal cord injuries. *Curr Infect Dis Rep*. 2011 Dec;13(6):544-51.
17. Cardenas DD, Hooton TM. Urinary tract infection in persons with spinal cord injury. *Arch Phys Med Rehabil*. 1995 Mar;76(3):272-80.
18. Bermingham SL, Hodgkinson S, Wright S, Hayter E, Spinks J, Pellowe C. Intermittent self catheterisation with hydrophilic, gel reservoir, and non-coated catheters: a systematic review and cost effectiveness analysis. *BMJ [Internet]*. 2013 [cited 2014 Aug 1];346:e8639. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3541473>
19. Siroky MB. Pathogenesis of bacteriuria and infection in the spinal cord injured patient. *Am J Med*. 2002 Jul 8;113 Suppl 1A:67S-79S.
20. Hooton TM, Bradley SF, Cardenas DD, Colgan R, Geerlings SE, Rice JC, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. *Clin Infect Dis*. 2010 Mar 1;50(5):625-63.
21. Gould CV, Umscheid CA, Agarwal RK, Kuntz G, Pegues DA, Healthcare Infection Control Practices Advisory Committee. Guideline for prevention of catheter-associated urinary tract infections 2009. *Infect Control Hosp Epidemiol*. 2010 Apr;31(4):319-26.
22. Gould CV, Umscheid CA, Agarwal RK, Kuntz G, Pegues DA, Healthcare Infection Control Practices Advisory Committee. Guideline for prevention of catheter-associated urinary tract infections 2009 [Internet]. Atlanta (GA): HICPAP; 2009. [cited 2014 Jul 29]. Available from: <http://www.cdc.gov/hicpac/pdf/CAUTI/CAUTIguideline2009final.pdf>
23. Nicolle LE. Catheter-acquired urinary tract infection: the once and future guidelines. *Infect Control Hosp Epidemiol [Internet]*. 2010 Apr [cited 2014 Jul 29];31(4):327-9. Available from: <http://www.jstor.org/stable/pdfplus/10.1086/651092.pdf?acceptTC=true&jpdConfirm=true>
24. Cardenas DD, Moore KN, Dannels-McClure A, Scelza WM, Graves DE, Brooks M, et al. Intermittent catheterization with a hydrophilic-coated catheter delays urinary tract infections in acute spinal cord injury: a prospective, randomized, multicenter trial. *Pm r*. 2011 May;3(5):408-17.
25. De Ridder DJ, Everaert K, Fernandez LG, Valero JV, Duran AB, Abrisqueta ML, et al. Intermittent catheterisation with hydrophilic-coated catheters (SpeediCath) reduces the risk of clinical urinary tract infection in spinal cord injured patients: a prospective randomised parallel comparative trial. *Eur Urol*. 2005 Dec;48(6):991-5.
26. Giannantoni A, Di Stasi SM, Scivoletto G, Virgili G, Dolci S, Porena M. Intermittent catheterization with a prelubricated catheter in spinal cord injured patients: a prospective randomized crossover study. *J Urol*. 2001 Jul;166(1):130-3.
27. Stensballe J, Looms D, Nielsen PN, Tvede M. Hydrophilic-coated catheters for intermittent catheterisation reduce urethral micro trauma: a prospective, randomised, participant-blinded, crossover study of three different types of catheters. *Eur Urol*. 2005 Dec;48(6):978-83.
28. Sarica S, Akkoc Y, Karapolat H, Aktug H. Comparison of the use of conventional, hydrophilic and gel-lubricated catheters with regard to urethral micro trauma, urinary system infection, and patient satisfaction in patients with spinal cord injury: a randomized controlled study. *Eur J Phys Rehabil Med*. 2010 Dec;46(4):473-9.
29. Esclarin De RA, Garcia LE, Herruzo CR. Epidemiology and risk factors for urinary tract infection in patients with spinal cord injury. *J Urol*. 2000 Oct;164(4):1285-9.

30. Pickard R, Lam T, MacLennan G, Starr K, Kilonzo M, McPherson G, et al. Types of urethral catheter for reducing symptomatic urinary tract infections in hospitalised adults requiring short-term catheterisation: multicentre randomised controlled trial and economic evaluation of antimicrobial- and antiseptic-impregnated urethral catheters (the CATHETER trial). *Health Technol Assess*. 2012 Nov;16(47):1-197.
31. Pickard R, Lam T, MacLennan G, Starr K, Kilonzo M, McPherson G, et al. Antimicrobial catheters for reduction of symptomatic urinary tract infection in adults requiring short-term catheterisation in hospital: a multicentre randomised controlled trial. *Lancet*. 2012 Dec 1;380(9857):1927-35.
32. Tambyah PA, Oon J. Catheter-associated urinary tract infection. *Curr Opin Infect Dis*. 2012 Aug;25(4):365-70.
33. Elden H, Hizmetli S, Nacitarhan V, Kunt B, Goker I. Relapsing significant bacteriuria: effect on urinary tract infection in patients with spinal cord injury. *Arch Phys Med Rehabil*. 1997 May;78(5):468-70.
34. Centers for Disease Control and Prevention. Catheter-associated urinary tract infection (CAUTI) event [Internet]. Atlanta (GA): CDC; 2014 Jan. [cited 2014 Jul 29]. Available from: <http://www.cdc.gov/nhsn/pdfs/pscManual/7pscCAUTIcurrent.pdf>
35. DeJong G, Tian W, Hsieh CH, Junn C, Karam C, Ballard PH, et al. Rehospitalization in the first year of traumatic spinal cord injury after discharge from medical rehabilitation. *Arch Phys Med Rehabil*. 2013 Apr;94(4 Suppl):S87-S97.
36. Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. *Infect Control Hosp Epidemiol*. 2011 Feb;32(2):101-14.
37. Centers for Disease Control and Prevention, Scott RD. The direct medical costs of healthcare-associated infections in U.S. hospitals and the benefits of prevention [Internet]. Atlanta (GA): CDC; 2009 Mar. [cited 2014 Jul 29]. Available from: [http://www.cdc.gov/hai/pdfs/hai/scott\\_costpaper.pdf](http://www.cdc.gov/hai/pdfs/hai/scott_costpaper.pdf)
38. Bryan CS, Reynolds KL. Hospital-acquired bacteremic urinary tract infection: epidemiology and outcome. *J Urol*. 1984 Sep;132(3):494-8.
39. Klevens RM, Edwards JR, Richards CL, Jr., Horan TC, Gaynes RP, Pollock DA, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Rep* [Internet]. 2007 Mar [cited 2014 Sep 15];122(2):160-6. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1820440>
40. Jahn P, Beutner K, Langer G. Types of indwelling urinary catheters for long-term bladder drainage in adults. *Cochrane Database Syst Rev*. 2012;10:CD004997.
41. Schumm K, Lam TBL. Types of urethral catheters for management of short-term voiding problems in hospitalised adults. *Cochrane Database Syst Rev*. 2008;2:CD004013. Review content assessed as up-to-date: 23 May 2010.
42. Schumm K, Lam TB. Types of urethral catheters for management of short-term voiding problems in hospitalized adults: a short version Cochrane review. *Neurourol Urodyn*. 2008;27(8):738-46.
43. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine; 2000 Feb 29 -. Identifier NCT01803919, Efficacy study of antimicrobial catheters to avoid urinary infections in spinal cord injured patients (ESCALE); 2013 Sep 10 [cited 2014 Jun 26]. Available from: <http://www.clinicaltrials.gov/ct2/show/NCT01803919>
44. Lederer JW, Jarvis WR, Thomas L, Ritter J. Multicenter Cohort Study to Assess the Impact of a Silver-Alloy and Hydrogel-Coated Urinary Catheter on Symptomatic Catheter-Associated Urinary Tract Infections. *J Wound Ostomy Continence Nurs*. 2014 Jun 11.

45. Beattie M, Taylor J. Silver alloy vs. uncoated urinary catheters: a systematic review of the literature. *J Clin Nurs*. 2011 Aug;20(15-16):2098-108.
46. Scott BM. Clinical and cost effectiveness of urethral catheterisation: a review. *J Perioper Pract*. 2010 Jul;20(7):235-40.
47. Trautner BW, Darouiche RO. Role of biofilm in catheter-associated urinary tract infection. *Am J Infect Control* [Internet]. 2004 May [cited 2014 Sep 15];32(3):177-83. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2963581>
48. Johnson JR, Kuskowski MA, Wilt TJ. Systematic review: antimicrobial urinary catheters to prevent catheter-associated urinary tract infection in hospitalized patients. *Ann Intern Med*. 2006 Jan 17;144(2):116-26.
49. Garibaldi RA, Mooney BR, Epstein BJ, Britt MR. An evaluation of daily bacteriologic monitoring to identify preventable episodes of catheter-associated urinary tract infection. *Infect Control*. 1982 Nov;3(6):466-70.
50. Frankel HL, Coll JR, Charlifue SW, Whiteneck GG, Gardner BP, Jamous MA, et al. Long-term survival in spinal cord injury: a fifty year investigation. *Spinal Cord*. 1998 Apr;36(4):266-74.
51. DeVivo MJ, Kartus PL, Stover SL, Rutt RD, Fine PR. Seven-year survival following spinal cord injury. *Arch Neurol*. 1987 Aug;44(8):872-5.
52. Drekonja DM, Kuskowski MA, Wilt TJ, Johnson JR. Antimicrobial urinary catheters: a systematic review. *Expert Rev Med Devices*. 2008 Jul;5(4):495-506.
53. Stenzelius K, Persson S, Olsson UB, Stjerneblad M. Noble metal alloy-coated latex versus silicone Foley catheter in short-term catheterization: a randomized controlled study. *Scand J Urol Nephrol*. 2011 Sep;45(4):258-64.
54. Omar MI, Lam T, Fisher E, N'Dow J. Effectiveness of short-term antiseptic and antimicrobial-coated urethral catheters in reducing catheter-associated urinary tract infections: Cochrane systematic review and meta-analysis. Abstract presented at: 29th Annual Congress of the European Association of Urology, EAU; 2014; 11-14 Apr; Stockholm (SE).
55. Independence Australia price list 2014. Section 1 - catheters & catheter packs [Internet]. Collingwood, Australia: Independence Australia Services; 2014. [cited 2014 Sep 15]. Available from: <http://www.independenceaustralia.com/uploads/HS%20Content/Section%201%20Catheters%20and%20Catheter%20Packs.pdf>
56. Plowman R. The socioeconomic burden of hospital acquired infection. *Euro Surveill*. 2000 Apr;5(4):49-50.
57. Karchmer TB, Giannetta ET, Muto CA, Strain BA, Farr BM. A randomized crossover study of silver-coated urinary catheters in hospitalized patients. *Arch Intern Med*. 2000 Nov 27;160(21):3294-8.
58. Burton DC, Edwards JR, Srinivasan A, Fridkin SK, Gould CV. Trends in catheter-associated urinary tract infections in adult intensive care units-United States, 1990-2007. *Infect Control Hosp Epidemiol*. 2011 Aug;32(8):748-56.

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