Catheter lock solutions are instilled into central venous access systems to have certain effects in this location. These access systems can be either dialysis catheters, Hickman-type lines or port-a-cath systems. The latter are used mainly in parenteral nutrition and for the administration of medication in oncology patients. These access systems are approved as medical devices and are CE marked. The central venous access is inserted in the subclavian, jugular or femoral veins.

The use of Antimicrobial Lock Solutions has been recommended in the “Hygiene Guideline complementing the German Dialysis Standard” and in the Position statement of European Renal Best Practice (ERBP)”. Pure heparin solutions containing no antimicrobial agent do not meet this criterion. Antibiotics are associated with the development of resistance which is a major drawback. Highly concentrated citrate solutions and taurodilute-citrate solutions are therefore conceivably useful in this application.

Highly concentrated citrate solutions (30% and 46.7%) cause major adverse effects such as cardiac arrests and embolisms that are a significant risk for the patient. TauroLock™, as an antimicrobial lock solution, has proven useful in dialysis, oncology, and parenteral nutrition for many years and has meanwhile become established in the prevention of catheter-related infections.

TauroLock™ prevents catheter infections:

The requirements of antimicrobial catheter lock solutions:

What should they do and what can they do?

The use of Antimicrobial Lock Solutions has been recommended in the “Hygiene Guideline complementing the German Dialysis Standard” and in the Position statement of European Renal Best Practice (ERBP)”. Pure heparin solutions containing no antimicrobial agent do not meet this criterion. Antibiotics are associated with the development of resistance which is a major drawback. Highly concentrated citrate solutions and taurodilute-citrate solutions are therefore conceivably useful in this application.

Highly concentrated citrate solutions (30% and 46.7%) cause major adverse effects such as cardiac arrests and embolisms that are a significant risk for the patient. TauroLock™, as an antimicrobial lock solution, has proven useful in dialysis, oncology, and parenteral nutrition for many years and has meanwhile become established in the prevention of catheter-related infections.

Highly concentrated citrate solutions (30% and 46.7%) cause major adverse effects such as cardiac arrests and embolisms that are a significant risk for the patient. TauroLock™, as an antimicrobial lock solution, has proven useful in dialysis, oncology, and parenteral nutrition for many years and has meanwhile become established in the prevention of catheter-related infections.

Does good hygiene compliance reduce catheter-related blood stream infection? A single centre experience

Ginger Chu, Kelly Adams, Gemma Fogarty and Liz Holliday

Submitted: 28 February 2018, Accepted: 8 May 2018

Abstract

**Background:** In Australia, more than 50% of end-stage kidney disease patients start haemodialysis treatment with a central venous catheter (CVC). While there are benefits of CVC access, they are associated with a high risk of bacteraemia infection. National guidelines for prevention of catheter-related infections advocate the importance of hand hygiene and asepsis practices, and for this reason, many dialysis units have regular auditing on hand hygiene and aseptic technique.

**Aim:** To report the relationship between hygiene audit results and infection rates in our facility.

**Method:** A hygiene audit tool was developed with 17 hygiene measures, categorised into three domains: environment, aseptic technique, and dressing care. This tool was used to observe nursing staff’s hand hygiene compliance and aseptic technique during CVC care across five regional and remote units. Audit results were collected from 2011 to 2015.

**Results:** A total of 350 audits were analysed, and the overall hygiene compliance was consistently high (85–99%). The relationship between mean hygiene score and infection rates was negative and the association was non-significant (p=0.7).

**Conclusion:** The overall infection rates have decreased in our facility, by an average of 76% across sites. The decrease in infection was correlated to interventions such as minimising catheter utilisation, implementation of antimicrobial dressings and streamlining protocols but not hygiene audit results. Good hygiene is fundamental in the care of a CVC; however, whilst all facilities should strive for excellent audit results, it should not be the sole focus to prevent catheter infection.

Keywords

Dialysis, catheter infection, renal, infection, hygiene.

**Ginger Chu** RN, MN (Clinical Studies), MN (Advanced Prac), PhD (c)
Clinical Nurse Consultant, John Hunter Hospital; NSW, Australia
Clinical Research Fellow, Hunter New England Local Health District; NSW, Australia
Conjoint Senior Lecturer, University of Newcastle, NSW, Australia

**Kelly Adams** RN, BN
Nurse Manager, Community Dialysis Units, John Hunter Hospital, NSW, Australia

**Gemma Fogarty**
Clinical Nursing Unit Manager, Maitland Community Dialysis Unit, John Hunter Hospital, NSW, Australia

**Liz Holliday**
Associate Professor of Biostatistics, School of Medicine and Public Health, University of Newcastle, NSW, Australia

**Correspondence to:** Ginger Chu, Wansey Community Dialysis Unit, Australia.
Email ginger.chu@hnehealth.nsw.gov.au
Introduction

According to the Australia and New Zealand Dialysis & Transplant Registry, more than 50% of end-stage kidney disease (ESKD) patients started haemodialysis (HD) treatment with a central venous catheter (CVC), and 10–20% will continue to receive the treatment via a CVC (ANZDATA Registry, 2017). While there are some benefits of a CVC, such as providing immediate access for HD treatment, they are also associated with a high risk of complications.

The Choices for Healthy Outcomes in Caring for End-Stage Renal Disease (CHOICE) Study revealed that CVCs, compared to arterio-venous fistulas (AVFs), are associated with 62% increase in inflammation, and subsequently the risk of death and cardiovascular events (Banerjee et al., 2014). Unfortunately, all types of vascular access have the potential for complications. In the last decade, infection and sepsis remain the most frequent and serious complications that caused mortality and hospitalisation in dialysis patients (Lok & Foley, 2013). Whilst many ESKD patients are predisposed to infection due to an altered immune system, nephrotic syndrome and reduced responsiveness to vaccines (Dalymple & Go, 2008), the majority of infections are caused by Staphylococcal aureus organisms associated with CVC use (Eleftheriadis et al., 2011).

Both Australian and US guidelines for prevention of catheter-related infections advocate hand hygiene and aseptic technique to reduce the associated risk (O’Grady et al., 2011; Polkinghorne et al., 2013). For this reason, many dialysis units have regular auditing on hand hygiene and aseptic technique. In this article, we assessed changes in catheter-related blood stream infections (BSIs) over five years across five regional and remote facilities, and its correlation to hand hygiene audit results and interventions implemented.

Pathogenesis of catheter infection

The auditing tool in our facility was developed based on the rationale of CVC infections. There are several factors that can cause catheter infections, which generally can be categorised into two main routes by which bacteria gain access into the blood stream: an extraluminal or intraluminal pathway (Lok & Mokrzycki, 2011). The extraluminal pathway involves initial contact with the skin surface, where skin organisms (from both patient and health care worker) and contaminated devices lead to organisms entering the blood stream (Gahlot et al., 2014). This type of contamination often can be minimised by good hand hygiene, strict aseptic technique during insertion, and adequate skin preparation prior to insertion. With up to 30% of HD patients likely to be carrier of S. aureus (Grothe et al., 2014), adequate skin preparation and decolonisation prior to a catheter insertion is essential to prevent extraluminal contamination.

The intraluminal pathway involves contamination of the patient’s CVC or catheter exit site where bacteria are introduced to the internal catheter surface (Lok & Mokrzycki, 2011). This often occurs during daily care of the CVC from inadequate cleansing procedure of the CVC or poor hand hygiene when accessing the catheter. The prevention of intraluminal contamination often involves review and improvement of clinicians’ practice related to CVC care; for example, hub cleaning at the commencement and completion of dialysis treatment, line access and dressing maintenance.

The audit tool

The CVC audit tool that we have developed focusses predominately on contamination via the intraluminal pathway, since catheter insertion within our facility is performed by the radiology department that has a separate management structure. The audit tool contains three domains (Environment, aseptic technique and dressing), containing a total of 17 binary (Yes/No) questions (Table 1). Since questions 14–17 were not routinely observed, they were omitted, leaving questions 1–13 for analysis. Three questions (Q9, 10 and 12) were reverse-coded so that a “yes” response retained the same interpretation (preventive of infection) across all questions. Each question scored 1 for yes, 0 for no, and the total score is ranged between 0 and 13.

Methods

The audit tool was used to record staff’s hygiene compliance. A number of interventions to reduce CVC infection were also implemented in two separate periods during the five-year auditing. These included the development of local CVC guidelines adhering to New South Wales policy and international guidelines, standardising documentation for CVC and dressing care, and providing education to non-renal staff who care for patients with a CVC. The outcome of the first intervention has been previously reported by us (Chu et al., 2013). In the second intervention period, we added strategies to reduce CVC utilisation by minimising the use of CVC as a temporary access. We also introduced a needleless device (Tego®) and an antimicrobial dressing (Kendall™ AMD disc) for routine CVC care. Hygiene audits were conducted six-monthly by the same group of assessors (clinical educators or clinical nurse consultants) using the same audit tool during the period 2011–2015. An infection episode was confirmed by at least one set of positive blood cultures obtained from either a CVC or peripheral blood, and classified as catheter-related infection when there was no other obvious source of infection. The denominator was collected by each unit head-counting patients every day. Numbers of patient months were calculated under the assumption that all patients receive dialysis three times a week and there were four weeks in each month.
Samples
Audit scores were obtained from three dialysis units (one tertiary hospital and two community/satellite centres) in 2011–2015. There were also two other (rural) community units observed, but due to small numbers, the data was combined into the larger community unit data. A total of 350 audits were analysed to compare the association between mean total hygiene score and six-monthly infection rates.

Statistical analysis
The association between mean total hygiene score and infection count was assessed using a Poisson mixed model, aggregating exposure and outcome data for individual sites within six-monthly time intervals. The model included fixed effects for the main hygiene score and time interval, and a random intercept for each site to account for repeated measures within sites. The logarithm of the total number of patient-months in the relevant six-monthly interval at each site was included as an offset. Parameter variances were estimated using a modified version of White’s heteroscedasticity-consistent covariance matrix estimator (White, 1980), to reduce the risk of Type I error rate inflation by the small sample size. The parameter estimate for the effect of the mean audit score was expressed as an incidence rate ratio (IRR) with 95% confidence interval and p-value.

Association between the delivery of hygiene-related interventions and infection rates were assessed using a similar Poisson mixed model including a fixed effect for study stage. This was a categorical variable with three levels: 1. pre-intervention (up to June 2011); 2. post the first intervention (from July 2011 to June 2014) and; 3. Post the second intervention (from July 2014 to December 2015). Parameter estimates for this variable were used to estimate the mean change in infection incidence (IRR) between intervention stages.

Table 1: Audit tool for central venous catheter (Permcath/Vascath) care in haemodialysis patients

<table>
<thead>
<tr>
<th>Facility: ___________________</th>
<th>Unit/Ward: ___________________</th>
<th>Date: __________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Performance indicator</th>
<th>MRN</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Is equipment wiped down before use, incl no items left on the table?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Is procedure applied in a stable environment (minimise air-flow)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Is PPE available to staff?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Is correct PPE applied — appropriate eye protection, gloves of correct type and gowning?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Is procedure conducted in an appropriate location and waste segregation and disposal satisfaction?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aseptic technique</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Compliant with 5 moments of hand hygiene (bare below the elbow pre-procedure)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Is dressing pack set up with aseptic technique: adequate extent of field and protection of all key parts?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Is dressing pack opened within 5 minutes prior to procedure: sequencing of procedure was appropriate (pre and during procedure)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Are staff and/or patient talking while attending procedure without masks?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Are staff and/or patient talking/coughing over open lumens without masks (changing caps)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Is clean non-touch technique performed to connect patient to the machine?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dressing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Is dressing moist prior to change?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Is dressing intact prior to change?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Is dressing applied with aseptic technique and correct PPE (bare below the elbow pre-procedure)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Are staff and/or patient talking over open exit site without masks?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Does dressing cover the exit site post dressing change?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Are caps and dressing changed weekly and documented?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Staff: _______________________________  Assessor: _______________________________
Results
Across the 350 audits, adherence to the hygiene recommendations was consistently high for all questions, with the majority (85–99.7%) of responses being “yes” for each question. CVC utilisation was reduced by 50% (44–20%) in our facility during this period.

A plot of infection rates against the mean audit score for six-monthly intervals at individual sites is represented in Figure 1. There was one outlying observation that had a low mean audit score and high event rate; otherwise, there was no apparent relationship between the sites’ mean six-monthly audit scores and corresponding event rates. Results from Poisson mixed model testing the association between mean audit score and infection rate are shown in Table 2. The first row shows results from analysis including all data points; and the second is excluding the aforementioned outlier. The association was non-significant in both analyses, which is consistent with the scatter plot (Figure 1). The analysis of all data suggested a negative relationship between the mean audit score and event rate, with each one score increase in the mean audit score associated with a 38% decrease in event rate (IRR=0.62). However, when the influential observation was excluded the estimated IRR was 1.00, indicating no relationship. Confidence intervals were wide, reflecting the small sample size.

There was a significant decrease in infection rates in the period after the first intervention, by an average of 76% across sites (IRR=0.24, P=0.038) (Figure 2). Compared to the period before either intervention, there was also a significantly lower infection rate after the second intervention (IRR=0.21, P=0.036) (Table 3). From the period after the first intervention to the period after the second intervention, there was a small but non-significant decrease in the infection rate (IRR=0.88, P=0.9).

Discussion
Infection is one of the leading causes of death in Australian HD patients (ANZDATA Registry, 2017). In particular, catheter-related BSIs is common, problematic and accounting for frequent hospital admissions and high mortality in this cohort (Miller et al., 2016). It is for this reason, over the years, there are worldwide initiatives such as Fistula First that encourages the use of AVF to decrease the use of CVCs. However, the process of selecting the most suitable dialysis access for an individual patient is complicated. A patient’s physical condition, social situation and personal preference need to be taken into consideration during the decision-making process, and therefore, there are (and will always be) patients who do better with a CVC rather than an AVF (Brown et al., 2017). While there is an increasing recognition for patient factors to be taken into consideration when planning for a dialysis access, maintaining the longevity of the HD catheter and preventing infective complications will remain the priority in dialysis practice.
In this report, we reviewed the correlation of audit results and infection rates from 350 observations in five different dialysis centres in the Lower Hunter Region. We found the interventions implemented in this project resulted in significant reduction in CVC infections, whereas the results of hygiene audits alone were not correlated to infection rates.

Hand hygiene and aseptic technique are the fundamental principles of infection control. Good compliance of hand hygiene can reduce nosocomial infections and S. aureus transmission (Pittet et al., 2000), but should not be seem as the only solution to reduce infection. Our results indicate that using a quality improvement approach and adherence to guidelines could reduce more than 50% of health care-associated CVC BSIs. A previous study in US involving 17 HD outpatient facilities also reported a significant reduction of catheter-related BSIs by implementing strategies based on the Centres for Diseases Control and Prevention (CDC) recommendations (Patel et al., 2013).

The strengths of this report include the use of a consistent method to report and document BSIs. The same audit tool and auditors used were also the strength of this project to avoid scoring bias. To the best of our knowledge, we are the first unit reporting the relationship between the hygiene score and infection rate within a dialysis unit, which will be useful information for clinicians and facility managers when interpreting audit data and designing strategies for BSI prevention. There were limitations to our analysis, such as the small number of participating units and numbers of observation. It is possible that the negative relationship is due to insufficient audit samples. However, this project was established with no funding, and due to the time required to conduct one audit, we would require additional staff to collect a larger sample.

To complete this project using limited health resources, we utilised the clinical nurse educator and nurse consultant to conduct the observations as part of individual skill/competence assessment. Therefore, only the units that are under the same management in our facility were included in this report. The number of observations were dependent on the number of CVC patients available in those units. With the intention of quality improvement instead of research, we therefore gathered the number of observations available at the time.

Conclusion

Whilst it is logical that good hand hygiene compliance contributes to infection prevention, there are other factors such as multiple comorbidities, advanced age, S. aureus carriers and a defective immune system that predispose dialysis patients to infection. Hand hygiene compliance by staff alone cannot inhibit these risk factors. Our experience has shown that a number of strategies are required when dealing with BSIs, not merely focussing on the audit results. We hope our experience has shown a positive example on how clinicians can identify a set of achievable and effective measures to reduce and prevent BSIs in dialysis units.

Acknowledgements

All staff and patients involved in the John Hunter Hospital Dialysis Unit, Warnsey, Raymond Terrace, Maitland, Singleton and Muswellbrook Dialysis Units.

The authors declare that there are no conflicts of interest and external funding received for this project.

References


TAKE THE FLEXIBLE APPROACH

ARGYLE™ FISTULA CANNULA FOR HAEMODIALYSIS

DATA & PRESSURE LIMITS

<table>
<thead>
<tr>
<th>Length (mm)</th>
<th>15G</th>
<th>16G</th>
<th>17G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Rate (ml/min)</td>
<td>450</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>Arterial Pressure (mmHg)</td>
<td>-214</td>
<td>-221</td>
<td>-188</td>
</tr>
</tbody>
</table>

Notes: Arterial Pressure should not exceed care provider guidelines. Results shown above achieved using 3-4cP Glyverin/Water Solution. The extracoporeal circuit includes devices in addition to the fistula cannula: observe the lowest flow rate for all devices within the system.

* The longest cannula was tested to represent the worst case scenario.