

Nursing care of arteriovenous fistula / arteriovenous graft

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GUIDELINES

- a. Skin at the intended cannulation site should be prepared with an alcohol based solution (Level II evidence)
- b. Cannulation should be undertaken using a clean or 'aseptic' technique (Level II evidence)
- c. Compared to the rope ladder technique, button-hole technique is associated with an increased risk of local and systemic infection and should not be routinely performed. (Level II evidence).

SUGGESTIONS FOR CLINICAL CARE

(Suggestions are based on Level III and IV evidence)

- It is suggested that assessment of the arteriovenous fistula / arteriovenous graft be undertaken each time prior to cannulation. Patency should be checked for adequate bruit and thrill, and the site inspected for signs of infection. (Level III evidence)
- Rope ladder technique is suggested for cannulation of arteriovenous fistulae and grafts.
- Button-hole technique maybe useful for patients with significantly reduced cannulation area of the arteriovenous fistula after discussion of the potential benefits and harms. (Level III evidence)
- We suggest strict adherence to infection control procedures be undertaken to minimise infection risk when using button hole technique for cannulation. (Level III evidence)
- Patients should be instructed on the care of the arteriovenous fistula / arteriovenous graft between cannulation sessions in particular: (Level III evidence)
 - Vein preservation: avoidance of cannulation in the effected limb
 - How to check for patency: clinical monitoring of bruit and thrill
 - Observing the site for signs of infection
 - The importance of identifying and reporting problems with vascular access
 - Adherence to good personal hygiene
 - Observe for signs of steal syndrome: hand going pale/blue, cold, with/out pain

IMPLEMENTATION AND AUDIT

- Conduct annual auditing of Staphylococcus aureus bacteraemia rates. Data for Methicillin Resistant Staphylococcus Aureus (MRSA), Vancomycin Resistant Enterococcus (VRE) and Extended Spectrum Beta-Lactamase (ESBL) should be included.
- Rupture of vascular access (fistula and graft), and complication rates of all vascular accesses within the unit should be recorded and reviewed regularly.
- Accredited staff training and education in infection control needs to be a mandatory requirement for all staff working with vascular access patients. Strict adherence to infection control policy must be promoted and evaluated regularly within the unit.

- Accredited ongoing staff training and education in cannulation technique should be undertaken by all staff accessing arteriovenous fistulae or grafts.

BACKGROUND

An effective haemodialysis treatment is dependent on a well-functioning vascular access which has good blood flow, excellent patency, and allows easy and repetitive cannulation with two needles. The arteriovenous fistula (AVF) provides the best access for longevity and lowest association with morbidity and mortality, followed by arteriovenous grafts (AVG's)[1]. Complications due to vascular access represent a large number of inpatient hospitalisations, and are an important cause of morbidity and mortality for the dialysis population. In a 1993 review of the United States Renal Data Service database, 15-16% of hospitalisations were vascular access related [2].

Thrombosis, stenosis, and infection are the three most prevalent complications of arteriovenous fistulas and grafts increasing reliance on central vascular catheters for dialysis access [3]

Patients dialyzing with AVG's or central venous catheters (CVC's) have a significantly higher relative risk for death, and in diabetics, AVG's and CVC's were associated with a higher overall relative risk of death of 1.41 and 1.54 respectively, when compared to AVF[4], Mortality is reduced by approximately 50% in patients who switch from a catheter to a permanent access (fistula or graft) as compared with those who remain catheter dependent[5]. Patients with central venous catheters in use for haemodialysis have a higher mortality risk, followed by those with an arteriovenous graft and then arteriovenous fistula, thus preservation of the dialysis patients' arteriovenous fistula or graft is critical to improved survival [4].

Infection remains one of the greatest risk factors to morbidity and mortality for the dialysis population. The ANZDATA report summary [6] has reported 11% of all deaths in the dialysis dependent population in 2010 were due to infection. The Canadian Morbidity Study showed a 4.5% rate for AVF infection and a 19.7% for AVG infection in the first year of follow up [2]. Infection remains second only to cardiovascular death as a cause of mortality accounting for 15-20% of patient death [2]. In addition, infections are the leading cause of all hospital admissions (102 admissions / 1,000 patient-years) in haemodialysis patients [7]. *Staphylococcus aureus* carriage in the nose and on the skin has been shown to be more common in patients receiving chronic haemodialysis than in the general population, and has also been found to be a major pathogen in this population, especially as the causative agent of access site infections [8].

Although fistulas require far fewer interventions than do grafts, they still develop stenosis and thrombosis [5]. Cannulation techniques, through tissue displacement and repair, may induce the formation of aneurysms and scars that in turn may favour the development of stenotic lesions and impact on fistula and graft survival [9]. The two major causes of thrombosis are: (a) damage to vessel wall and endothelium due to continuous cannulation and (b) stenosis, a narrowing of the vessel wall predominantly caused by intimal hyperplasia [10] Thrombosis accounts for approximately 80% of graft failures. Thrombosed grafts usually have an underlying stenosis, and timely detection and correction of the stenosis will prevent graft thrombosis [5].

Needle infiltration of new fistulas is a relatively frequent complication, which occurs most commonly in older patients. A single major infiltration prolongs catheter dependence by a median of 3 months [5]. Good cannulation technique can reduce the incidence of needle infiltration.

Repeated cannulation of AVF's and in particular AVG's places the patient at risk for infection via bacterial contamination. Bacteria can either be directly introduced into the circulation leading to either local infection of the access or bacteraemia [2]. Strict adherence to infection control policies is paramount to preventing access site infections.

Good cannulation technique, examination of the fistula or graft, and implementing proven infection control practices are essential to minimizing risk factors which compromise an efficient vascular access. Patient education on monitoring the site and prompt reporting of any changes, and adherence to good hygiene, are crucial in preventing AVF/AVG failure.

This guideline will examine the nursing care of arteriovenous fistulas and grafts and provide evidence-based recommendations for nursing care of haemodialysis vascular access.

SEARCH STRATEGY

Databases searched: MeSH terms and text words for arteriovenous fistulas and grafts were combined with MeSH terms and text words for retrograde and antegrade cannulation, rope ladder, buttonhole, bevel, and cannula, and combined with MeSH terms and text words for chlorhexidine, anti-infective agents, and cannulation technique, and then combined with Cochrane highly sensitive search strategy for randomised controlled trials as well as other study types such as prospective and retrospective cohort studies. MeSH terms and text words for renal dialysis, hemofiltration, dialysis and end-stage renal disease were also added to the search to identify haemodialysis specific publications. The search was carried out in Medline (1948 to November 2011). The Cochrane Renal Group library was also searched for current trials.

Date of search: November 2011.

WHAT IS THE EVIDENCE?

Patency

In a prospective observational study by van Loon and colleagues [11] 158 chronic haemodialysis patients with newly created vascular accesses were followed for a period of 6 months (from time of first cannulation), to evaluate the complications caused by cannulation, and the clinical consequence of failed cannulation. Variation in sound of bruit by using the stethoscope ($p < 0.01$), haematoma ($p < 0.003$), swelling ($p < 0.0009$), and the direction of the arterial needle (antegrade) ($p < 0.003$) were all significant factors for use of central venous catheter (CVC) dependence or single needle (SN) dialysis in arteriovenous grafts, with multiple regression modelling showing antegrade arterial needle direction as a single predictor for cannulation-related complications. For the AVF group, the univariate analysis showed haematoma ($p < 0.0001$) and arm swelling ($p < 0.004$) to be significant determinants for CVC usage and SN dialysis. Multiple regression model showed only the presence of haematoma were predictive ($p < 0.0001$) for CVC dependence. Alterations in vascular access sound by stethoscope auscultation were shown to be predictive for cannulation-related complications and arteriovenous graft failure.

In a review by Allon and Robbin it was found that clinical monitoring of the vascular access has a relatively high (69%-93%) predictive value for angiographically confirmed stenosis, with 80% for abnormal physical examination of the graft. However, the success of clinical monitoring in detecting stenosis is highly dependent on the proficiency of the dialysis staff and the consistency with which they monitor the graft [12]. When a stenosis is present, the continuous sound of the bruit will change to a distinctly separate sound [13]. The clinical finding of a pulsatile mass and a systolic bruit in auscultation usually allows correct diagnosis of pseudoaneurysm [14]. Assessment of vascular access involves inspection, palpation, and auscultation. It is necessary that vascular access be evaluated prior to cannulation using these three aspects of nursing care [13]. Blood flow through the vascular access should be assessed regularly and should include listening with a stethoscope for a bruit, feeling a palpable thrill at the anastomosis, and observing the site for signs and symptoms of local and systemic infection. Poor prognostic signs, such as significant decrease in the thrill, or intensity or character of the bruit, should be referred immediately back to the surgeon for prompt evaluation and intervention. Signs of infection should be reported quickly for medical management. Patient education on monitoring the access should start when selection of access type is discussed [15].

Skin preparation

Picheansathian's [16] systematic review analysed 41 studies relating to the effect of alcohol-based solutions in reducing microorganisms on the hands or agar plates, compliance with hand hygiene among health care workers (HCW's) during introduction of alcohol-based solutions and time involved in using alcohol hand rubs. Their findings demonstrated that alcohol-based hand rubs remove microorganisms including bacteria, viruses, fungi and multiple resistant micro-organisms from hands of

personnel more effectively than hand washing with non-medicated soap or other antiseptic agents and water. At equal concentrations, N-propanol is the most effective alcohol of those commonly used and ethanol the least. Isopropanol 90% is as effective as N-propanol 60% in anti-microbial activity, and the combination of 61% ethanol and 1% chlorhexidine gluconate was even more effective in reducing counts of micro-organisms and produced residual antibacterial properties on the skin.

A randomised controlled trial study by Kaplowitz and colleagues [17] examined overall and site-specific infection rates, microbial aetiologies of infection and risk factors for infection. Patients were randomly assigned either a clean or an aseptic technique for cannulation, and all study participants were blind to which technique they were allocated. Their results found an overall infection rate of 4.7 infections per 100 dialysis months, 1.3 access-site infections per 100 dialysis months, and the rate for bacteraemia was 0.7 cases per 100 dialysis months. Advanced age ($p=0.02$), poor hygiene ($p=0.0004$) and number of hospitalisations ($p=0.0002$) were risk factors for infection in general, while only poor hygiene ($p=0.0002$) was a risk factor for vascular access-site infections. They concluded that sterile preparation of the skin was no more effective at preventing infection than was clean technique ($p=0.80$).

In an earlier study by Kaplowitz et al [8] a comparison was made on the effectiveness of removing skin micro flora by performing a sterile skin preparation and comparing it to a clean technique. Their results found that the sterile skin technique was no more effective in removing skin flora from the access site than the clean technique. Skin flora at the access site was also correlated with the level of patient hygiene. For this analysis, patients with intermediate and poor hygiene were combined and compared with those with good hygiene. Staph aureus was present in 2 of 386 skin cultures from patients with good hygiene compared with 8 of 225 skin cultures taken from patients with poor hygiene for cultures taken after, but not before, skin preparation ($P=0.002$). Furthermore, when staph aureus was present after skin preparation, it occurred with significantly heavier growth in patients with poor hygiene ($P=0.005$). They also found that when coagulase-negative staphylococci was present on the skin of the access site before skin preparation, they were significantly more likely to be present in patients with poor hygiene ($P=0.02$). Their study concluded that staph aureus skin colonisation is a risk factor for the subsequent development of staphylococcal access site infections. Also those patients with poor hygiene were shown to have a significantly increased incidence of skin colonisation of the access site with staph aureus after skin preparation, thus poor hygiene is a major risk factor for the development of access site infections.

Grabe and colleagues [18] performed a randomized clinical trial evaluating the effect of skin disinfection before intravenous cannulation. 187 patients were randomly allocated to two groups, one using 70% isopropylalcohol as skin disinfectant, the other using no skin disinfectant. Cannula swabs were taken after each cannulation and sent for culture. No significant difference was found between the two groups or between culture positive/negative cannulae, with a contamination rate of 22.6% after use of 70% isopropylalcohol, and 22.0% after cannulation with no disinfectant. Thus it was concluded that 70% isopropylalcohol before cannulation cannot prevent or even reduce intraluminal contamination and therefore is not the product of choice for skin disinfection.

An Australian study by Wellard and Palaster [19] compared the effects of disinfection of haemodialysis cannulation sites with povidone iodine, and with a combination of chlorhexidine gluconate solution and alcohol wipes. A total of 1,811 treatments of adults on haemodialysis using a functioning arteriovenous fistula were observed. Each subject acted as their own control by using the A-B-A-B design to re-introduce each method of disinfection to repeat the study conditions. No inflammation or infections of cannulation sites were observed and no method was shown to be a more effective skin disinfectant than the other.

Cannulation technique

There are no studies on optimal cannulation for AV grafts however the rope ladder technique is the preferred method as it reduces the formation of pseudoaneurysms. It is presumed that repetitive dialysis needle sticks in a small region of the graft results in a weakening of the wall, with subsequent expansion [20]. The rope ladder technique is the regular use of the entire vessel length, with each needle being spaced back from the last site and then back along the length again. This technique has resulted in less aneurysm formation as a result of fewer punctures per area [21] Thus it is recommended for cannulation of AVG [22].

The alternative buttonhole technique is repeated use of the same entry point, with the same entry angle and depth each time the fistula is cannulated [23]. The technique has been advocated to reduce needling pain and aneurysmal formation. Three randomized trials have assessed the buttonhole technique compared to the rope ladder. MacRae *et al.* assessed 140 in-centre haemodialysis patients [24] over an 8 week period for cannulation pain but assessed AVF patency and infectious complications over 12 months of follow-up. Pain scores were similar between the two groups, median score of 1.2 rope ladder (range 0.4-2.4) versus 1.5 (0.5-3.4) for buttonhole needling ($P=0.57$). However more patients in the buttonhole group (28.6%) experienced excess pain (mean pain score >3) compared with the rope ladder (15.7%), $P=0.07$; OR 2.15 (95%CI: 0.87-5.44). While rates of haematoma formation was higher in the rope ladder group (436 per 1000 dialysis session compared to the buttonhole group (295/ per 1000 sessions, $p=0.03$) increasing difficulty in needling was seen in the buttonhole group ($p=0.002$). Infectious complications were seen more frequently in the buttonhole group. Rates of localized infection were higher (50 versus 22.4 per 1000 dialysis sessions, $p=0.003$) in addition to nine and 3 episodes of abscess formation and *Staphylococcus aureus* bacteraemia respectively seen in the buttonhole group versus none in the rope ladder group

Chow and colleagues [25] randomized 70 adult participants with ESRD on HD from multiple in-centre and home training units to either the buttonhole technique (35 participants) or the control (rope ladder) group (35 participants) with 6 months follow-up. There were no differences between quality-of-life subscales at baseline or follow-up, and no difference either in the appearance of the access site, the number of cannulation attempts, type of access, or haemostasis time. Pain at the cannulation site during the dialysis session was recorded more frequently in the buttonhole group ($p=0.012$). Forty seven complications were recorded in 28 participants; 17 in the buttonhole group experienced 33 complications, and 11 in the rope ladder experienced 14 events. Fistula complications (not specified) and haematoma formations were higher in the buttonhole group. Of the 5 participants who had a fistula infection, four were cannulating with the buttonhole technique and one with rope ladder. The rope ladder participant exhibited signs of infection at the access site although there was no growth in blood cultures and swab. Three of the participants in the buttonhole group presented with redness and inflammation of the exit site. Blood cultures and exit swab revealed no growth. The 4th participant with infection in the BH group was hospitalized with fever, swelling and tenderness of the fistula, blood cultures grew *Klebsiella pneumoniae* and negative *staphylococcus*.

Struthers and colleagues [26] conducted a randomised controlled trial in three dialysis centers and involved 56 patients haemodialysing with AVF. Complications arising due to needling technique were higher in the rope ladder group including increased bleeding from sites (11 vs 17 episodes) and infiltrations (19 vs 27). Each group had one fistula thrombosis and one episode of infection occurred in the buttonhole group. Less local anaesthetic was seen in the buttonhole group compared to the rope-ladder group ($P=0.01$).

Labriola *et al.* [27] conducted an cohort study of access infection rates of patients as they transitioned from rope ladder cannulation of their AVF's to button hole cannulation, over a period of 9 years. Infectious events were ascertained during four periods: 1) RL technique in all 2) transition to BH 3) BH in all before education workshops and 4) BH in all after workshops. 57 infectious events occurred during follow-up (0.31 events/1,000 AVF-days) with 24 local infections without bacteraemia; 15 cases of local infection with bacteraemia; and 18 cases of AVF-related bacteraemia without local AVF infection. The relative risk (RR) of infectious events was significantly lower during period 1 compared to period 3 (RR 0.39; 95%CI: 0.19 to 0.78, $P=0.006$). It was also lower for the combined periods 1 and 2 compared to period 3 (RR 0.38; 95%CI: 0.19 to 0.73, $P=0.003$) In multivariate analysis, period 3 was the most significant association with infection count (RR 2.28; $P=0.03$), followed by AVF location (upper arm vs forearm) RR1.71, ($P=0.09$) During the period immediately after the education workshops (2008B), the incidence of infectious events per 1,000 AVF days decreased significantly compared to the period just before the educational workshops (RR 0.16, 95%CI: 0.017 to 0.56; $P=0.03$), however there was a non-significant increase in 2009 and 2010 compared to 2008B period, RR 2.95, (95%CI:0.70 to 20.06) $P=0.2$ and RR of 2.11 (95%CI: 0.31 to 17.73; $P=0.4$) respectively. Complicated infectious events was significantly lower during periods 1 and 2 combined compared to period 3 (RR 0.051, 95%CI: 0.003 to 0.87; $P=0.01$). There was a significantly higher incidence of complicated infectious events in period 3 compared to period 4 (RR 6.37, 95%CI: 1.09 to 138.4, $P=0.04$). There were three deaths due to endocarditis, two in period 3 caused by *Staph. aureus* and one in period 4 due to *Staph. epidermidis*. Two other deaths in period 3 occurred due to *S. aureus* septicaemia.

Ludlow [28] performed a prospective cohort study in 2010 assessing the effects of cannulating the arteriovenous fistulae using the buttonhole technique from the patient and nurse perspectives, using questionnaires rating confidence levels about buttonhole technique, pain experienced and frequency of cannulation complications. High levels of staff confidence in buttonhole technique and fewer cannulation complications occurred as staff became more experienced with the technique and tracks were established. There was no significant difference in arterial/venous pressures or haemostasis noted. A significant decrease in pain from the patients was reported in both the arterial and venous needles ($P=0.002$ and $P=0.010$ respectively) when using the button hole technique.

An observational cohort study comparing hospital admission rates for vascular access complications between alternate nightly haemodialysis (NHD) and conventional haemodialysis (CHD), by van Eps et al. [29] demonstrated an increased risk of septic dialysis access events when NHD and button hole cannulation were used simultaneously: incidence rate ratio 3.0 (95% confidence interval 1.04-8.66) ($P=0.04$). Rates of positive blood cultures were not significantly increased in patients on NHD or using BH technique for either univariate or multivariate analysis. Mortality rates in the NHD group were 5.8 (0.18-13.54) compared to 4.91 (1.97-10.11) deaths / 100 patient-years in the CHD group. Deaths in the NHD group were due to sepsis (4 patients) and one sudden cardiac event. In the CHD group, deaths were due to medical comorbidities.

Ward et al [23] performed an audit of buttonhole cannulation in 53 adult haemodialysis patients. 93% of patients reported shorter venepuncture bleeding time after needle removal, 81% less pain on needling and 80% reported improved appearance of the fistula compared to sharp needle RL technique. There were no incidents of infection, either local, systemic, or skin commensals. No patients experienced any adverse events such as major bleeding or aneurysmal dilatation.

A retrospective pre-post comparison study was undertaken by Nesrallah and colleagues [30] of staphylococcus aureus bacteraemia (SAB) rates after establishing Mupirocin prophylaxis (MP) in 56 patients on home nocturnal haemodialysis via AV fistula, all using the button hole technique of cannulation. A total of 11 blood cultures from 10 patients were positive for staphylococcus aureus, all in association with local features of infection at the AVF. One was thought to present a recurrent infection, 4 had evidence of metastatic infection. During the pre-intervention phase, 8 SAB's were detected while only 2 were detected post introduction of Mupirocin prophylaxis (MP). Infection rate was 0.32 infections/1000 AVF-days before MP and 0.03 infections /1000 AVF-days after MP, with an odds ratio of 6.4 (95%CI: 1.3 to 32.3; $P=0.02$) for developing SAB before Mupirocin prophylaxis. 298 patients receiving conventional haemodialysis using the rope ladder technique (total of 206,584 AVF-days) were used as controls. Only one SAB was identified and was associated with local AVF infection, corresponding to an infection rate of 0.005/1000 AVF-days.

Van Loon and colleagues [31] investigated the effect of both buttonhole and rope ladder cannulation techniques on the incidence of vascular access (VA) complications in 145 patients dialyzing with arteriovenous fistulae. The buttonhole method of cannulation had more unsuccessful cannulations ($p<0.001$), though less haematoma formation ($p<0.0001$). Formation of aneurysms in the RL technique group occurred significantly more than in the buttonhole technique ($p<0.0001$). Angioplasty was higher in the rope-ladder group ($p<0.001$) however access-related infection was higher in the buttonhole group ($P<0.001$) where there were four antibiotic treated infections in the BH group but none in the RL group ($P<0.001$).

Doss, Schiller and Moran [32] performed a retrospective study of data from their dialysis centre of a total of 137 in-centre patients, and 60 patients home haemodialysing since initiation of button hole technique. 10 episodes of septicaemia have occurred in 10 in-centre patients, 3 of which were Staphylococcus aureus infections. 13 button hole site infections occurred in the same group, with Staph. aureus in 10 patients and methicillin resistant Staph. aureus infection in three patients. During the same period, six episodes of septicaemia were reported in the home dialysis group, three of which were Staph. aureus. No episodes of button hole site infections were reported in the home group. Overall results indicated an infection rate of 0.16/1,000 patient days in the in-centre setting and 0.19/1,000 patient days in the home setting. One infection in an in-centre patient resulted in death.

A second prospective observational study by Verhallen et al. [33] also comparing the buttonhole and rope ladder techniques of arteriovenous fistulae cannulation found that buttonhole technique had significant benefits. Parameters measured at 1.5, 3, 6 and 18 months included cannulation ease, bad sticks, pain, compression time after cannula removal, oozing of blood alongside the cannula, re-

bleeding of the puncture site after compression, signs of infection, aneurysm formation and thrombosis, cannulating ease and pain (VAS score). Data of the RL technique were obtained at baseline. BH technique data over the 18 months were averaged and compared with baseline data. Results showed: improved cannulating ease, the VAS-score decreased from 2.9 ± 2.4 at baseline to 1.3 ± 1.2 ($P=0.002$); a significant decrease in the incidence of bad sticks from 0.8 ± 1.4 at baseline to 0.3 ± 0.6 incidents per 2 weeks ($P=0.03$); a decrease in compression time from 8.7 ± 3.6 to 7.6 ± 4.0 ($P=0.004$); however there was no significant difference in the cannulating pain between rope-ladder VAS-score of 2.3 ± 2.2 and buttonhole 1.6 ± 2.0 ($P=0.12$). Existing aneurysms that had developed with the RL technique also showed a tendency to flatten out when using the buttonhole technique. No aneurysms occurred with the button hole technique. Three patients developed local skin infection of one of their button holes, and 1 thrombosis developed in one patient after 5 months of button hole use. In conclusion, the button hole technique can be a good alternative to the RL technique for patients who self cannulate, especially in patients with frequent re-insertions, when a patient suffers from cannulating stress, or when the fistula provides too little space to use the RL technique.

In the prospective cohort study by Marticorena et al. [34] it was found that buttonhole cannulation facilitates the healing of damaged skin and stabilisation of the aneurysmal dilatation. The study evaluated the impact of a modified buttonhole (BH) cannulation technique on fistulae with aneurysmal dilatation and damaged skin. Significant improvement was noted in the haemostasis time post-haemodialysis. Cannulation of the arterial buttonhole was significantly less painful than the venous for each patient ($P=0.001$) with significant pain improvement after completion of the tunnel tracks and again after 6 months of dull needling (Friedman test, $p<0.001$). At 1 year, 2 aneurysms were less visible and palpable. And there was no increase in size of any existing aneurysm, and no incidence of thrombosis or flow reduction. However, one patient developed a staphylococcus aureus septic arthritis, a second developed staphylococcus aureus endocarditis although this took place 21 months after BH access creation, and a third patient developed contact dermatitis secondary to prolonged skin contact with chlorhexidine.

SUMMARY OF THE EVIDENCE

Patency

Alteration in VA sound (bruit) was shown to be predictive for cannulation-related complications and AVG failure. This concept is supported by the KDOQI guidelines which state that physical examination of the vascular access can identify low flows associated with impending graft failures and the presence of aneurysms. Careful inspection and monitoring of the vascular access is of paramount importance in the early detection of vascular site related infection and patency issues.

Skin preparation

Alcohol-based hand rubs remove microorganisms including bacteria, viruses, fungi and multiple drug resistance microorganisms from hands of personnel more effectively than hand washing with non-medicated soap or other antiseptic agents and water. No skin disinfectant was shown to be more effective than another. Sterile skin technique was no more effective in removing skin flora from the access site than the clean technique. Removal of staph aureus from the skin prior to cannulation is critical to prevention of vascular access site infection particularly in patients with poor hygiene.

Cannulation technique

Two of three recent randomised trials demonstrate increased infection complications with buttonhole cannulation compared to rope ladder without clear benefits on needling pain. Increased infectious complications including death from bacterial sepsis were also seen in the majority of the observational cohort studies. The minor benefits seen in the observational studies have not been reflected in the randomised trial data and thus buttonhole should not be routinely performed.

WHAT DO THE OTHER GUIDELINES SAY?

Kidney Disease Outcomes Quality Initiative: [35]

Clinical practice guidelines:

Guideline 3. Cannulation of fistulae and grafts and access of haemodialysis catheters and port catheter systems

The use of aseptic technique and appropriate cannulation methods, the timing of fistula and graft cannulation, and early evaluation of immature fistulae are all factors that may prevent morbidity and may prolong the survival of permanent dialysis accesses.

3.1 Aseptic techniques:

3.1.1 For all vascular accesses, aseptic technique should be used for all cannulation and catheter access procedures. (A) Figure 1

3.2 Maturation and cannulation of fistulae:

3.2.1 A primary fistula should be mature, ready for cannulation with minimal risk for infiltration, and able to deliver the prescribed blood flow throughout the dialysis procedure. (See Table 3) (B)

3.2.2 Fistulae are more likely to be useable when they meet the Rule of 6s characteristics: flow greater than 600 mL/min, diameter at least 0.6 cm, no more than 0.6 cm deep, and discernible margins. (B)

3.2.3 Fistula hand-arm exercise should be performed. (B)

3.3 Cannulation of AVGs:

Grafts generally should not be cannulated for at least 2 weeks after placement and not until swelling has subsided so that palpation of the course of the graft can be performed. The composite PU graft should not be cannulated for at least 24 hours after placement and not until swelling has subsided so that palpation of the course of the graft can be performed. Rotation of cannulation sites is needed to avoid pseudoaneurysm formation. (See Table 4. (B)

Clinical practice recommendations:

For guideline 3: Cannulation of fistulae and grafts and access of dialysis catheters and ports

3.1 Cannulation skill:

Staff should be appropriately trained and observed for technical mastery before cannulating any AV access. Only those with said technical mastery should be allowed to cannulate a new fistula. A protocol for minimizing vessel damage should be used for cannulation failure.

Recannulation should be attempted only when the cannulation site is healed and the vessel is assessed to be normal and appropriate for cannulation.

Heparin management should be reviewed on a case-by-case basis to minimize post dialysis bleeding.

3.2 Self-cannulation:

Patients who are capable and whose access is suitably positioned should be encouraged to self-cannulate. The preferred cannulation technique is the buttonhole.

3.3 Buttonhole:

Patients with fistula access should be considered for buttonhole (constant- site) cannulation. (See protocol in CPG 3.)

3.4 Elevation of arm for swelling:

The AVG access arm should be elevated as much as possible until swelling subsides, which may take as long as 3 to 6 weeks. Increase in symptoms requires urgent evaluation.

For guideline 4: Detection of access dysfunction: monitoring, surveillance, and diagnostic testing.

4.1 Monitoring the access:

4.1.1 Access patency should be ensured before each treatment before any attempts to cannulate the access.

4.1.2 All caregivers, including fellows in training, should learn and master the methods for examining a vascular access.

4.1.3 Access characteristics, such as pulsatility and presence of thrill, as well as flow and pressure, should be recorded and tracked in a medical record and be available to all caregivers of the VAT. Figure2.

Recommendations for guideline 5: Treatment of fistula complications

5.1.1 The patient should be taught to examine his or her access daily, while at home, for thrombosis.

UK Renal Association: [36]

Guideline 4.2 – Needling technique

We suggest that buttonhole is the preferred needling technique. (2B)

Rationale –

There has been a recent focus on the type of needling technique employed to access

arteriovenous fistulas. There are three broad techniques:

- a) area puncture (cannulation in a restricted area)
- b) rope ladder technique (needling is progressively moved up and down the length of the fistula)
- c) buttonhole technique (a tract is formed down which cannulas can be placed)

In a recent study cannulation of AV fistulae was compared using the button hole and rope ladder techniques (1). Those in the buttonhole group had more unsuccessful cannulations compared to the rope ladder group but the former was associated with a significantly reduced risk of haematoma and aneurysm formation. Intervention with angioplasty was higher in the patients using the rope ladder technique. There was however an increased risk of infection associated with the buttonhole technique. It is therefore recommended that the buttonhole technique is the preferred method for fistula cannulation but enhanced measures for infection reduction should be employed. Area puncture is the least favoured technique.

Guideline 4.3 – Vascular access surveillance

We suggest that systematic observation and advanced surveillance should be employed to predict and prevent access failure. (2C)

Rationale –

Inspection can occur on every occasion the access is used. Observation can detect local swelling, infection, the presence of a haematoma, aneurysm and potentially the presence of stenosis. Palpation and auscultation can complement inspection particularly when a stenosis is suspected. These three steps (look, feel, listen) should be routine in the assessment of vascular access.

Guideline 6.2 – Prevention of arteriovenous aneurysmal formation

We suggest that prevention of aneurysmal formation with good needling technique is appropriate and is the cornerstone for preserving arteriovenous fistulae. (2C)

Rationale –

Vascular malformations of either arteriovenous fistulae or grafts are common. Prevention with good needling technique is appropriate and is the cornerstone of preserving arteriovenous fistulae. Aneurysm formation can lead to graft or fistula failure with thrombosis. It can also lead to sudden rupture of the access with potentially serious consequences. There are no good evidence based guidelines concerning the management of aneurysms in this setting but careful liaison with vascular radiology and surgical colleagues can develop local strategies for intervention.

Canadian Society of Nephrology: [37]

Recommendation –

IV. Infection Prevention in the Vascular Access

1. Instruct all staff and patients on infection control measures. **(Grade D, opinion)**

Rationale –

Proper infection control procedures can significantly reduce the risk of infection. Catheter care and accessing the patient's circulation should be sterile procedures. During catheter connect and disconnect procedures, nurses and patients should wear a surgical mask or face shield. Nurses should also wear gloves during all connect and disconnect procedures, although the evidence for sterile *versus* non sterile gloves is inconclusive.

Use a clean technique for needle cannulation for all cannulation procedures. Ensure that only trained dialysis staff or caregivers change haemodialysis catheter dressings and manipulate catheters that access the patient's bloodstream and minimize contamination.

European Renal Best Practice (Position Statement): [38]

Guideline 2.1. Clinical evaluation and non-invasive ultrasonography of upper extremity arteries and veins should be performed before vascular access creation (Evidence level II).

Rationale –

Careful selection of suitable vessels based on objective evaluation, is required for successful creation of a functioning AVF. Physical examination is used for pre-operative assessment and access planning. This includes assessment of the distal arterial pulse and the presence, diameter and course of the superficial fore- and upper arm veins. Physical examination may be difficult in obese patients and depends on the experience of the examiner.

Guideline 4.1. Nurses and medical staff should be involved in vein preservation and monitoring of the vascular access. Every patient with chronic kidney disease should have a declared plan for preserving the vascular access and potential access sites (Evidence level IV).

Rationale –

A substantial part of the pre-dialysis care is the preservation of veins in both arms, favouring the use of the veins of the dorsum of the hand for blood sampling, infusions and transfusions [1]. After placement of the initial vascular access, preferably an autogenous AVF, the correct needling technique has a favourable influence on maturation and fistula lifespan. Nurses play a pivotal role in the care for vascular access: they see the patient every dialysis, perform cannulation and assess function of the vascular access [2]. The vascular access should be checked before each cannulation by inspection and palpation.

Guideline 4.2. Any staff involved in handling vascular access or cannulating veins in renal patients should be adequately trained and be in a continuous training scheme for access management (Evidence level IV).

Rationale –

Nurses generally have more practical experience and skills for cannulating and managing vascular access than physicians. Written protocols for cannulation, handling central venous catheters and physical examination of the vascular access prior to cannulation should be provided.

Guideline 4.3. An autogenous fistula should be cannulated when adequate maturation has occurred (Evidence level III).

Guideline 4.4. The rope ladder technique should be used for cannulation of grafts (Evidence level III).

Rationale –

While few scientific data concerning access handling and the outcome of specific cannulation techniques have been reported, the rope ladder technique is advised for the cannulation of AV grafts [5], to avoid graft disintegration and the formation of pseudo-aneurysms. In autogenous fistulae, particularly those with only a short vein segment available for needling, the buttonhole method is preferred over area puncture.

Guideline 5.1. Prior to any cannulation, autogenous arteriovenous fistulae and grafts should be assessed by physical examination (Evidence level IV).

Rationale –

It is necessary to evaluate the vascular access clinically prior to any cannulation, both in autogenous AV fistulae and AV grafts. Inspection may reveal swelling, infection, haematoma, aneurysm or stenoses.

Palpation evaluates the characteristic thrill and the intravascular pressure as it may differ between a pre- and a post-stenotic vessel segment. Post-stenotic collapse of the vein after elevation of the arm above the heart is proof of the haemodynamic relevance of a stenosis in autogenous AV fistulae. Auscultation is indicated if a stenosis is suspected and a high-pitched bruit can be heard in the presence of a stenosis. Clinical evaluation for the monitoring of prosthetic grafts may be difficult because of their rigidity, however, has been reported reliable to indicate flow changes [1]. Usually, no dilatation is observed, except in case of cannulation-related pseudo-aneurysm formation. Any suspicion of complications arising from the clinical examination should be confirmed by objective measurements.

International Guidelines

Australian Guidelines for the Prevention and Control of Infection in Healthcare: [39]

1. Routine hand hygiene

Hand hygiene must be performed before and after every episode of patient contact. This includes: before touching a patient; before a procedure; after a procedure or body substance exposure risk; after touching a patient; after touching a patient's surroundings. Hand hygiene must also be performed after the removal of gloves. **Grade B**

2. Choice of product for routine hand hygiene practices

For all routine hand hygiene practices in healthcare settings, use alcohol-based hand rubs that

- contain between 60% and 80% v/v ethanol or equivalent **Grade B**; and
- meet the requirements of EN1500. **Grade GPP**

3. Choice of hand hygiene product when hands are visibly soiled

If hands are visibly soiled, hand hygiene should be performed using soap and water. **Grade B**

4. Hand hygiene for *Clostridium difficile* and non-enveloped viruses

Hand hygiene should be performed using soap and water when *Clostridium difficile* or non-enveloped viruses such as noro virus are known or suspected to be present and gloves have not been worn. After washing, hands should be dried thoroughly with single-use towels. **Grade GPP**

6. Use of face and protective eyewear for procedures

A surgical mask and protective eyewear must be worn during procedures that generate splashes or sprays of blood, body substances, secretions or excretions into the face and eyes. **Grade C**

7. Wearing of gloves

Gloves must be worn as a single-use item for:

- each invasive procedure;
- contact with sterile sites and non-intact skin or mucous membranes; and
- activity that has been assessed as carrying a risk of exposure to blood, body substances, secretions and excretions.

Gloves must be changed between patients and after every episode of individual patient care. **Grade GPP**

8. Sterile gloves

Sterile gloves must be used for aseptic procedures and contact with sterile sites. **Grade GPP**

SUGGESTIONS FOR FUTURE RESEARCH

1. Bacteraemia rates in AVF and AVG related to needling technique.
2. A comparison of *Staph. aureus* bacteraemia rates in nocturnal haemodialysis patients using button hole technique with those using rope ladder technique
3. Evaluation of the efficacy of simple clinical examination of the vascular access (patency, bruit and thrill) on early detection and intervention of vascular access complications.
4. Randomised studies evaluating the impact of improved patient hygiene on access site infection rates, such as comparing those washing with an antibacterial lotion prior to cannulation against a control group.
5. Further trials on cannulation techniques and needle bevel position would strengthen the existing limited knowledge available.

CONFLICT OF INTEREST

Edwina Vale, Pamela Lopez-Vargas and Kevan Polkinghorne have no relevant financial affiliations that would cause a conflict of interest according to the conflict of interest statement set down by KHA-CARI.

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APPENDICES

Table 1. Characteristics of included studies

Study ID	N	Study design	Participants	Follow up	Comments and results
Patency					
Van Loon et al (2009)[11]	158	Prospective observational study	Chronic haemodialysis patients with newly created arteriovenous fistulae (AVF) or arteriovenous grafts (AVG) Multicentre, Netherlands	6 months	<ul style="list-style-type: none"> Rope-ladder technique was used on all patients 37% of patients with AVFs and 19% of patients with AVGs had >10 miscannulations AVG group - univariate analysis found the following to be significant for central venous catheter (CVC) use or single needle (SN) dialysis: variation in sound of bruit by using the stethoscope ($p<0.01$); haematoma ($p<0.003$); swelling ($p<0.0009$); and the direction of the arterial needle (antegrade) ($p<0.003$). Multiple regression model showed antegrade arterial needle direction ($P<0.007$) as a single predictor for cannulation-related complications in the AVG group. For the AVF group, the univariate analysis showed haematoma ($p<0.0001$) and arm swelling ($p<0.0004$) to be significant determinants for CVC usage and SN dialysis. Multiple regression model showed only the presence of haematoma ($p<0.0001$) to be predictive for CVC dependence or SN dialysis. Cannulation-related complications ($p<0.0001$) were associated with failure in the AVF group (univariate analysis) Conclusions - Haematoma formation occurred more frequently in AVF's than grafts, and is a significant predictor for the need for CVC/SN dialysis. Retrograde arterial needling was the single predictor for successful cannulation outcome of AVG's ($P<0.009$) [univariate analysis]
Skin preparation					
Picheansathian (2004)[16]	41 studies	Systematic review	26 studies- effectiveness of alcohol-based solutions 7 studies – compliance with hand hygiene 14 studies – skin problems 3 studies – time involved using alcohol hand rubs	N/A	<ul style="list-style-type: none"> Effectiveness of alcohol-based solutions: 70% ethanol reduced more bacteria than 62% ethanol Alcohol-based hand rinses met the standard requirement within 30sec of application whereas alcohol-based hand gels did not. Immediately after application, microbial reduction by alcohol-based solutions was significantly greater compared to 4% chlorhexidine gluconate (CHG) weighted mean difference (WMD) = 1.10, 95%CI: 1.01 to 1.19 There was no statistical difference in microbial hand counts following pre-surgical hand disinfection with an alcohol-based product or 4%CHG/7.5% povidone iodine (0.21 vs 0.33) Using 1% CHG and 61% ethanol (CHG/ethanol) hand preparation proved to be significantly greater in bacterial reduction factor (RF) than 4% CHG products at all times ($P<0.05$)

Study ID	N	Study design	Participants	Follow up	Comments and results
					<ul style="list-style-type: none"> • Hand rubbing with an alcohol-based solution reduced methicillin-resistant staphylococcus aureus (MRSA) more efficiently than non-medicated soap (WMD = 2.60, 95%CI: 2.23 to 2.98) and 4%CHG (WMD = 4.13, 95%CI: 3.55 to 4.71) • 10% povidine 1%iodine detergent had a higher removal rate against MRSA than 70%ethyl alcohol (RF = 4.39 vs 3.27) • Alcohol-based hand disinfectants are also more effective against vancomycin resistant enterococcus (VRE) than non-medicated handwash products and 4% CHG (RF = 5.10 vs 4.80 vs 3.22) respectively • Three studies found no significant increase in skin problems due to the use of alcohol-based solutions. And five studies found that alcohol-based solutions were less damaging to the skin than CHG. • Hand washing with water and soap consumes more time (60sec) than hand rubbing with an alcohol-based solution (15sec) P=0.01.
Kaplowitz et al (Dec. 1988)[17]	71	RCT	Adult patients dialysing in-centre with an AV fistula or graft. Randomised into 2 groups: 'Clean technique' (37 patients) or 'Sterile technique' (34 patients. Single centre, USA	12 months (676 dialysis months)	<ul style="list-style-type: none"> • There were 1.3 access-site infections per 100 dialysis months. • S. aureus was the causative agent for seven of the nine access-site infections • Overall infection rate was 4.7 infections per 100 dialysis months • Rate for bacteraemia was 0.7 cases per 100 dialysis months. • There was a significant difference in the number of hospital days during the study period: mean of 15.5 days in the clean technique group vs 21 days for the sterile technique group (P=0.002) • There was no significant difference in access-site infection rates in the clean technique group 5/37 (13.5%) vs 4/34 (12%) in the sterile technique group (P=0.80) • Advanced age (P=0.02), poor hygiene (P=0.0004) and a lower Karnofsky activity rating (P=0.05) were significantly related to infections • Only poor hygiene (p=0.002) was a risk factor for vascular access-site infections.
Kaplowitz et al (July 1988)[8]	71	RCT	Adult patients dialysing in-centre with an AV fistula or graft. Randomised into 2 groups: 'Clean technique' (37 patients) or 'Sterile technique' (34 patients. Single centre, USA	12 months (676 dialysis months)	<ul style="list-style-type: none"> • Difference between clean and sterile technique is the use of non-sterile gloves or sterile gloves with sterile field respectively • The only difference between the groups was that patients in the sterile group had 10 more months of haemodialysis prior to the study (P=0.01) • Incidence of Staph. aureus remaining on the skin was higher in the sterile technique group than in the clean technique group, 35% vs 6% respectively (P=0.04). • There was no significant difference between the two techniques in the removal of all microorganisms (P=0.99). • Significant relationship between nasal carriage and skin colonisation for S. aureus (P=0.005); Micrococcus species (P<0.001) and Gram-negative bacilli (P=0.004) • S.aureus was present in 2 of 386 patients with good hygiene compared with 8 of 225 patients with poor hygiene (P=0.002). When present in patients with

Study ID	N	Study design	Participants	Follow up	Comments and results
					<p>poor hygiene there was a significant heavier growth (P=0.005)</p> <ul style="list-style-type: none"> • Sterile skin technique was no more effective in removing skin flora from the access site than the clean technique (P=0.99) • Staph aureus skin colonisation prior to skin preparation was significantly associated with subsequent Staph. aureus access site infection (P=0.02).
Grabe, et al (1985) [18]	187	RCT	<p>187 surgical patients undergoing any surgical procedure requiring cannulation.</p> <p>Group1 (137) = 70% isopropyl alcohol; Group2 (50) = no skin disinfectant</p>	7 weeks	<ul style="list-style-type: none"> • Cannula swabs were taken after each cannulation and sent for culture. • Contamination rate of 22.6% after use of 70% isopropylalcohol, and 22.0% after cannulation with no disinfectant. • No significant difference between the two groups or between culture positive/negative cannulae. • Multiresistant organisms were detected in the 70% isopropyl alcohol group only • There was no correlation between time elapsing from hospitalization to cannulation and intraluminal contamination in either of the groups • 70% isopropylalcohol before cannulation did not prevent or reduce intraluminal contamination
Wellard and Palaster (1996) [19]	17	Prospective cohort with treatment reversal	<p>Adults on haemodialysis with a functioning AV fistula. Two methods of skin disinfection were used on participants before cannulation. Method A – Povidone Iodine and Method B – Chlorhexidine gluconate and alcohol. Single centre, Melbourne Australia</p>	12 months	<ul style="list-style-type: none"> • 971 sites were disinfected with povidone iodine and 840 sites with chlorhexidine gluconate and alcohol. • No inflammation or infections of cannulation sites were observed with either cleaning agent. Thus neither method was shown to be a more effective skin disinfectant than the other. • Patients preferred chlorhexidine to iodine. • Total cost was reduced using chlorhexidine.
Cannulation technique					
MacRae et al (2012) [24]	140	RCT	<p>Adult haemodialysis patients with a stable AVF were randomly assigned to either rope ladder (standard needling – SN) or buttonhole needling (BN).</p> <p>Single centre, Canada</p>	14 months	<ul style="list-style-type: none"> • Pain score was similar between the two groups: SN group median pain score = 1.2 (IQR: 0.4-2.4) versus BN = 1.5 (0.5-3.4) P=0.57 • Compared to the SN group, more patients in the BN group had excess pain (mean pain score >3), OR = 2.15 (95%CI: 0.87-5.44). P=0.07 • Rate of haematoma formation was higher in the SN group (436/1000 dialysis sessions) compared with 295/1000 sessions in the BN group, P=0.03 • More patients in the SN group had at least one haematoma (25/70) versus (12/70) in the BN group, P=0.01) • Rate of localized infection was 22.4/1000 dialysis sessions in the SN group compared with 50/1000 sessions in the BN group, P=0.003 • Overall there were 3 patients in the BN group who had an episode of

Study ID	N	Study design	Participants	Follow up	Comments and results
					Staphylococcus aureus bacteraemia, and nine who developed an abscess at the needling site, requiring antibiotics, compared with no episodes of bacteraemia or abscesses in the SN group (P=0.003)
Chow et al (2011) [25]	70	RCT	Incident and prevalent haemodialysis patients, allocated to intervention group (buttonhole BH) or control group (usual practice – rope ladder RL). Multicentre, Australia	6 months	<ul style="list-style-type: none"> • 17 patients in the BH group experienced 33 complications • 11 participants in the control group experienced 14 complications • Infection at the cannulation site: 4 patients in the BH group and 1 in the control group (P= 0.11) • Haematomas and pain at the cannulation site was more common in the BH group (P<0.05)
Struthers et al (2010) [26]	56	RCT	Haemodialysis patients from three centres in UK, dialyzing with an AVF. Participants were randomised to button-hole (BH) (experimental group n=28) or rope ladder technique (control group n=28)	6 months	<ul style="list-style-type: none"> • Use of local anaesthetic was reduced in the buttonhole group (9/22 patients) compared with (1/25 patients) in the control group (P<0.01) • No difference in pain scores, however the BH group had a higher pain score 2.5 out of 10 vs 1 for the control group • AVF's in the buttonhole group increased in size by 1%±22% compared with 30%±7% (P<0.01) for the control group • Strong preference for BH needling in patients (21/22) and staff (15/23) as opposed to RL technique. • Complications – bleeding from needle sites: 11 in BH group, 17 in RL group; infiltrations: 19 in the BH group, 27 in RL; thrombosis: 1 in each group; fistula infection: 1 in BH group only.
Labriola et al (2011) [27]	177	Observational cohort study	All patients on maintenance haemodialysis therapy using an AVF were included. Patients were transitioned from rope-ladder (RL) to button-hole (BH) technique Single centre, Belgium	9.5 years	<ul style="list-style-type: none"> • Infectious events were ascertained during four periods: Period1: RL technique in all Period 2: switch to BH Period 3: BH in all before workshops Period 4: BH in all after workshops • There was a total of 186,481 AVF-days, 193 AVFs • 57 infectious events occurred during follow-up (0.31 events/1,000 AVF-days: with 24 local infections without bacteraemia; 15 cases of local infection with bacteraemia; and 18 cases of AVF-related bacteraemia without local AVF infection • The relative risk (RR) of infectious events was significantly lower during period 1 compared to period 3 (RR 0.39; 95%CI: 0.19 to 0.78, P=0.006). It was also lower for the combined periods 1 and 2 compared to period 3 (RR 0.38; 95%CI: 0.19 to 0.73, P=0.003) • The RR for period 3 was higher than period 4 (RR 1.29, 95%CI: 0.69 to 2.49, P=0.4) although not statistically significant • In multivariate analysis, period 3 was the most significant association with infection count (RR 2.28; P=0.03), followed by AVF location (upper arm vs forearm) RR1.71, (P=0.09) • During the period immediately after the education workshops (2008B), the incidence of infectious events per 1,000 AVF days decreased significantly compared to the period just before the educational workshops (RR 0.16, 95%CI: 0.017 to 0.56; P=0.03), however there was a non-significant

Study ID	N	Study design	Participants	Follow up	Comments and results
					<p>increase in 2009 and 2010 compared to 2008B period, RR 2.95, (95%CI:0.70 to 20.06) P=0.2) and RR of 2.11 (95%CI: 0.31 to 17.73; P=0.4) respectively</p> <ul style="list-style-type: none"> • Complicated infectious events was significantly lower during periods 1 and 2 combined compared to period 3 (RR 0.051, 95%CI: 0.003 to 0.87; P=0.01). • There was a statistically significant higher incidence of complicated infectious events in period 3 compared to period 4 (RR 6.37, 95%CI:1.09 to 138.4, P=0.04) • There were three deaths due to endocarditis, two in period 3 caused by Staph. aureus and one in period 4 due to Staph. epidermidis. Two other deaths in period 3 occurred due to S. aureus septicaemia
Ludlow (2010) [28]	54	Prospective cohort study	25 renal dialysis nurses and 29 haemodialysis patients dialysing with an AVF. Multicentre study in the UK.	3 months	<ul style="list-style-type: none"> • High levels of staff confidence in BH technique, fewer cannulation complications occurred as staff became more experienced with the technique and tracks were established. • Significant decrease in pain reported for both the venous and arterial cannulations. Mean (SD) pain rating for venous cannulation: at the start of the study 2.6 (1.4) vs end of study 1.9 (1.1), P=0.01; for the arterial cannulation: 2.3 (1.2) vs 1.7 (0.8), P=0.002 • There was a non-significant increase in the frequencies of infiltration 4.2%, poor flow 6.5% and infection 4.8% • 20.7% of patients (6/29) experienced at least one episode of the 'trampoline effect' • No significant difference in arterial/venous pressures or haemostasis. • Unit level costs increased due to more expensive BH needles and additional supplies (an additional \$358.80 per patient/year)
Van Eps et al (2010) [29]	235	Observational cohort study	Adult patients haemodialysing with an AVF or AVG. Buttonhole (BH) technique was used in most fistulae and rope-ladder (RL) for all grafts. Two groups were observed: night HD (done at home – intervention group) and chronic HD (in centre – control group). Single centre, Australia	12-14 months	<ul style="list-style-type: none"> • There was no significant change in non-septic access events with night haemodialysis (NHD). Univariate analysis incidence rate ratio (IRR) 0.99 (0.53-1.85), P=0.97; and multivariate analysis IRR 1.10 (0.43-2.81), P=0.85 • Patients on NHD and using BH technique compared to chronic haemodialysis (CHD) patients, had significantly higher septic access event rates on multivariable analysis IRR 3.0 (1.04-8.66), P=0.04. • Rates of positive blood cultures were not significantly increased in patients on NHD or using BH technique for either univariate or multivariate analysis • Mortality rates in the NHD group were 5.8 (0.18-13.54) compared to 4.91 (1.97-10.11) deaths / 100 patient-years in the CHD group. Deaths in the NHD group were due to sepsis (4 patients) and one sudden cardiac event. In the CHD group, deaths were due to medical comorbidities. • In the NHD group 71% of positive blood cultures were gram-positive of which 60% were S. aureus, compared to 64% S. aureus identified in the 58% gram-positive cultures in the control group

Study ID	N	Study design	Participants	Follow up	Comments and results
					<ul style="list-style-type: none"> 32% of cultures isolated Gram negative organisms in the CHD group compared with 7% in the NHD group.
Ward et al (2010) [23]	53	Audit / observational	Adult haemodialysis patients were introduced to the buttonhole technique. Single centre, UK	14 months (median)	<ul style="list-style-type: none"> 12/53 (23%) patients started de novo, whilst 41/53 (77%) had been using RL technique 93% of patients reported shorter venepuncture bleeding time after needle removal; 81% less pain on needling; 80% improved appearance of the fistula compared to sharp needle RL technique Fistula recirculation rates fell from 9.3±0.4% to 8.3±0.3% (P=0.016) for patients who had previously been dialysing using the RL technique No patient experienced any adverse events such as infections, major bleeding or aneurysmal dilatation since starting on the BH technique
Nesrallah et al (2010) [30]	56	Pre and post non-randomised study	Patients on home nocturnal haemodialysis via AVF using buttonhole cannulation. Topical mupirocin prophylaxis was introduced and bacteraemia events ascertained pre and post intervention. Single centre, Canada	286.9 patient-years [2.7±1.7 yrs/subject pre-intervention; 4.3±1.9 post-intervention]	<ul style="list-style-type: none"> 6 patients died but only one of these was access-related 10 patients had positive blood cultures for S.aureus which were associated with local infection of the AVF. Four patients had metastatic infection and one of these died after ceasing HD During the pre-intervention phase, 8 S. aureus bacteraemias (SAB) were detected while only 2 were detected post introduction of Mupirocin prophylaxis (MP) Infection rate was 0.32 infections/1000 AVF-days before MP and 0.03 infections /1000 AVF-days after MP. With an odds ratio of 6.4 (95%CI: 1.3 to 32.3; P=0.02) for developing SAB before mupirocin prophylaxis 298 patients receiving conventional haemodialysis (total of 206,584 AVF-days) were used as controls. Only one SAB was identified and was associated with local AVF infection, corresponding to an infection rate of 0.005/1000 AVF-days
Van Loon, et al. (2010) [31]	145	Prospective observational study	Patients dialysing with AVF using the buttonhole (BH) technique were compared with patients using rope ladder (RL) technique. Multicentre study, Netherlands	9 months	<ul style="list-style-type: none"> There were more unsuccessful cannulations in the BH group 8.1 (7.0) mean (SD) compared with 3.7 (4.7) for the rope-ladder group (P<0.0001), though less haematoma formation 2.0(3.7) vs 14.0(15.6) respectively (P<0.0001). More aneurysms in the RL technique group 67% vs 1% in patients in the BH group (p<0.0001) More pain reported in the BH group (P<0.001) and fear (P<0.002) than in the RL group, though more incidence of use of local anaesthetic in the RL group (P<0.001). There were 10 interventions in the BH group compared with 41 in the RL group (P<0.001) There were four antibiotic treated infections in the BH group but none in the RL group (P<0.001)
Doss et al. (2008) [32]	197	Retrospective study	137 in-centre haemodialysis patients and 60 home haemodialysis patients cannulated using the	Not stated	<ul style="list-style-type: none"> Infection rate of 0.16/1,000 patient days in the in-centre group and 0.19/1,000 patient days in the home setting group In-centre group: 10 episodes of septicaemia in 10 patients, with S. aureus infection in three patients, Streptococcus Group B in one and

Study ID	N	Study design	Participants	Follow up	Comments and results
			buttonhole technique. In-centre patients dialysed three times/week, home haemodialysis patients dialyzed six times/week. Single centre, Canada		<ul style="list-style-type: none"> gram-positive cocci in two patients 13 buttonhole site infections occurred in the same group with cultures positive for S.aureus in 10 patients and methicillin resistant S. aureus (MRSA) in three patients Home dialysis group: six episodes of septicaemia; cultures positive for S. aureus in three patients, Staph. epidermidis in one and gram-positive cocci in two patients. No buttonhole site infections in this group In-centre patients required multiple cannulators while at home patients either self-cannulated or a single dialysis helper inserted the needles
Verhallan et al (2007)[33]	33	Prospective observational study	Button-hole (BH) technique was introduced to patients on home haemodialysis. All patients self-cannulated. Single centre, Netherlands	18 months	<ul style="list-style-type: none"> BH technique showed a significant improvement of cannulating ease, visual analogue scale score (VAS-score) of 2.9±2.4 at baseline to 1.3±1.2 (P=0.002) during follow-up The incidence of bad sticks decreased significantly with BH technique from 0.8±1.4 to 0.3±0.6 incidents per 2 weeks (P=0.03). Pain scores were less for BH 1.6±2.0 compared with 2.3±2.2 for rope-ladder technique, though not significantly (P=0.12) There was no increase in compression time: 8.7±3.6 minutes at baseline compared with 7.6±4.0 min during follow-up (P=0.004) Three patients developed local skin infection of one of their buttonholes. No aneurysms occurred with BH technique, 1 thrombosis developed in one patient after 5 months of BH use Existing aneurysms that had developed with the RL technique showed a tendency to flatten out.
Marticorena et al (2006) [34]	14	Prospective cohort study	Chronic haemodialysis patients dialysing with a problematic fistula. Single centre, Canada	12 months.	<ul style="list-style-type: none"> Significant improvement in the haemostasis time post-HD median (IQR) 20min (15, 40) at the onset of buttonhole (BH) creation, compared with 13min (9, 20) at the end of the study (P<0.001) Cannulation of the arterial buttonhole was significantly less painful than the venous cannulation over the course of the study (P=0.001) Significant pain improvement occurred after completion of the tunnel tracks and again after 6 months of dull needling (P<0.001) Complications: 1 patient developed Staph. aureus septic arthritis; another patient developed S. aureus endocarditis, although this took place 21 months after BH access creation; a third patient developed contact dermatitis secondary to prolonged skin contact with chlorhexidine At 1 year, 2 aneurysms were less visible and palpable. There was no increase in size of any existing aneurysm, and no incidence of thrombosis or flow reduction

Table 2a. Methodological quality of randomised trials

Study ID (author, year)	Method of allocation concealment *	Blinding			Intention-to-treat analysis †	Loss to follow up (%)	Comments ‡
		(participants)	(investigators)	(outcome assessors)			
Skin preparation							
Kaplowitz et al (Dec. 1988; July 1988)[8, 17]	Computer-generated	No	No	Yes	Yes	27%	–
Grabe et al (1985)[18]	Not specified	No	No	No	Yes	0%	–
Cannulation technique							
MacRae et al (2012) [24]	Permuted block design	No	No	Yes	Yes	0%	–
Chow et al (2011)[25]	Sealed envelopes	No	No	No	Yes	16%	–
Struthers et al (2010) [26]	Randomized in blocks	No	No	No	No	16%	–

* Choose between: central; third party (e.g. pharmacy); sequentially labelled opaque sealed envelopes; alternation; not specified.

† Choose between: yes; no; unclear.

‡ Quality score – “How successfully do you think the study minimised bias?” Choose between: very well (+); okay (Ø); poorly (–).

Table 3a – Results and quality rating for dichotomous outcomes

Outcomes	Study ID (author, year)	Intervention group (no. of patients with events/no. of patients exposed)	Control group (no. of patients with events/no. of patients exposed)	Relative risk (RR) [95% CI]	Risk difference (RD) [95% CI]
Skin preparation					
Access-site infection	Kaplowitz et al (Dec. 1988)[17]	4/34	5/37	0.87 (0.25, 2.98)	-0.02 (-0.17, 0.14)
Culture positive	Grabe et al (1985)[18]	31/137	11/50	1.03 (0.56, 1.89)	0.01 (-0.13, 0.14)
Cannulation technique					
Death	Chow et al (2011)[25]	2/35	1/35	2.0 (0.19, 21.06)	0.03 (-0.07, 0.12)
Access-site infection	Chow et al (2011) [25]	4/35	1/35	4.0 (0.47, 34.02)	0.09 (-0.03, 0.20)
	Struthers et al (2010) [26]	1/28	0/28	3.0 (0.13, 70.64)	0.04 (-0.06, 0.13)
Haematoma	MacRae et al (2012) [24]	12/70	25/70	0.48 (0.26, 0.88)	-0.19 (-0.33, -0.04)
	Chow et al (2011) [25]	4/35	0/35	9.0 (0.50, 161.13)	0.11 (-0.0, 0.23)
Pain	MacRae et al (2012) [24]	20/70	11/70	1.82 (0.94, 3.51)	0.13 (-0.01, 0.26)
	Chow et al (2011) [25]	5/35	0/35	11.0 (0.63, 191.69)	0.14 (0.02, 0.27)

Table 3b. Results and quality rating for continuous outcomes

Outcomes	Study ID (author, year)	Intervention group (mean [SD])	Control group (mean [SD])	Difference in means (95% CI)
Localised infection	MacRae et al (2012) [24]	50.0 (SD not provided)	22.4 (SD not provided)	27.6; P=0.003

Figure 1.

Table 2. Skin Preparation Technique for Subcutaneous AV Accesses

<ul style="list-style-type: none"> • Locate, inspect and palpate the needle cannulation sites prior to skin preparation. Repeat prep if the skin is touched by the patient or staff once the skin prep has been applied, but the cannulation not completed. • Wash access site using an antibacterial soap or scrub and water. • Cleanse the skin by applying 2% chlorhexidine gluconate/70% isopropyl alcohol or 70% alcohol and/or 10% povidone iodine as per manufacturer's instructions for use.
<p>Notes:</p> <ul style="list-style-type: none"> • 2% chlorhexidine gluconate/70% isopropyl alcohol antiseptic has a rapid (30 s) and persistent (up to 48 hr) antimicrobial activity on the skin. Apply solution using back and forth friction scrub for 30 seconds. Allow area to dry. Do not blot the solution. • Alcohol has a short bacteriostatic action time and should be applied in a rubbing motion for 1 minute immediately prior to needle cannulation. • Povidone iodine needs to be applied for 2-3 minutes for its full bacteriostatic action to take effect and must be allowed to dry prior to needle cannulation. • Clean gloves should be worn by the dialysis staff for cannulation. Gloves should be changed if contaminated at any time during the cannulation procedure. • New, clean gloves should be worn by the dialysis staff for each patient with proper infection control measures followed between each patient.

National Kidney Foundation, KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: Hemodialysis Adequacy, Peritoneal Dialysis Adequacy and Vascular Access. *Am J Kid Dis.* 2006. **48**: S1-S322.

Figure 2.

Table 17. Summary of Physical Examination

Inspection	Examine for erythema, swelling, gangrene, change of size of aneurysms over time.
Palpation	<p>Feel for intravascular pressure along the veins; examine for segmental differences in quality.</p> <p>Feel for elevated/low skin temperature; check the quality of pulsation along arteries and veins.</p> <p>Check for pain caused by finger pressure.</p>
Auscultation	<p>Check for the presence of typical low-frequency bruit with systolic and diastolic components.</p> <p>Examine for abnormal high-frequency bruit produced by turbulence due to a stenosis.</p>

National Kidney Foundation, KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: Hemodialysis Adequacy, Peritoneal Dialysis Adequacy and Vascular Access. *Am J Kid Dis.* 2006. **48**: S1-S322.