Introduction

Individuals with chronic kidney disease who are haemodialysis (HD)-dependent require well-functioning vascular access to enable effective regular treatment. The native arteriovenous fistula (AVF) has reduced risk of complication and increased long-term viability; therefore, it is considered the optimal vascular access. Appropriate cannulation technique is vital to maintain fistula viability and reduce risk of access-related complications. Two differing cannulation techniques predominate the HD community worldwide, “rope laddering” and “buttonholing”. A third technique, “area puncturing” is less widely used. The following literature review was undertaken to assess the clinical benefits of buttonhole cannulation for HD.

Search strategies: Current literature published that discusses buttonhole cannulation of native arteriovenous fistulas was systematically searched utilising three different electronic databases: Current Index of Nursing and Allied Health Literature (CINAHL), Scopus and Medline via Pubmed.

Findings: Five major themes were identified: increased infection rates, reduced pain, decreased aneurysm development, reduced haematoma formation and shortened time to achieve haemostasis post-treatment.

Discussion: Buttonhole cannulation may provide several benefits to HD-dependent individuals with a functioning arteriovenous fistula, many of which may be attributed to the use of blunt needles. It requires a different needling technique to rope ladder cannulation. Strict adherence to aseptic technique is vital as clinical benefits of the buttonhole technique may be overshadowed by an increase in infective complications.

Conclusion: The buttonhole technique potentially may provide benefits for individuals with frail arteriovenous fistulae or limited cannulation area. Careful consideration must be given regarding patient preference, fistula characteristics and the primary cannulator before selecting cannulation technique.

Keywords
Arteriovenous fistula, haemodialysis, cannulation, buttonhole, end-stage kidney disease, nursing.

Abstract

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every time the AVF is accessed; consequently scarring and tunnel formation occurs (White, 2006).

The buttonhole technique, first used in Europe with individuals who had limited AVF cannulation sites, was described in a seminal paper by Twardowski and Kubara (1979). It requires the AVF to be repeatedly punctured at exactly the same site and the same manner (Twardowski & Kubara, 1979). Initially cannulation is with sharp needles to enable establishment of a fibrous puncture track. Ideally, the same person should cannulate until an established track is created to reduce the risk of track malformation (Ball, 2006). Dull or blunt needles are used following track formation, thus reducing risk of vessel damage. All individuals cannulating the AVF following track or buttonhole formation must use the same method (McCann et al., 2009). Research surrounding buttonhole cannulation has revealed potential access-related complications are decreased or in some cases, eliminated. Reduced pain, improved ease and speed of cannulation and less haematoma formation have been reported when compared with the rope-ladder technique. The buttonhole technique has been effectively used for successful cannulation of challenging fistulas in rural and remote regions and as a method to reduce the risk of AVF-related complications (Hartig & Smyth, 2009). It is particularly suited to individuals with very short AVF access, fragile fistulas or who experience ongoing cannulation difficulties. Individuals who self-cannulate may benefit from buttonhole cannulation (Ball, 2006).

The purpose of this literature review is to ascertain if the buttonhole technique reduces the risk of vascular access complications when compared with the rope-ladder technique in adults who are HD-dependent. Papers which have not been included in similar reviews previously have been added.

Search strategies
Current literature published concerning buttonhole cannulation of native AVFs was systematically searched for utilising three electronic databases: Current Index of Nursing and Allied Health Literature (CINAHL), Medline via Pubmed and Scopus. Together, these three databases provide a wide range of access to literature relevant to buttonhole cannulation. Key search terms included: “haemodialysis”, “hemodialysis”, “cannul*”, “AVF”, “arteriovenous” and “fistula”. The Boolean operators AND or OR were utilised to ensure an effective search. Depending on which database was used, several hundred articles were listed. Many of these are not relevant to the topic; therefore, the search was narrowed by adding the terms “buttonhole” or “constant site”. Search strategies are listed below:

1. (Haemodialysis OR hemodialysis) AND (cannul* OR needle*).
2. AVF OR arteriovenous OR fistula.
3. 1 AND 2.
4. (Haemodialysis OR hemodialysis) AND 2.
5. 4 AND (buttonhole OR “constant site”).

Limits included: date range (2000–2011) which ensured the review investigates recent research, and language (English only). The final search yielded a total of 32 articles indexed in CINAHL, 41 in Medline and 49 in Scopus. Many articles were duplicated in all three databases; therefore, the final searches yielded a total of 66 original articles. Twenty-eight were immediately excluded. The remaining 38 articles warranted further investigation. Following comprehensive evaluation, 16 articles complied with the inclusion criteria for this review. Interestingly all these papers were written within the past five years. The majority of them were small studies and few were randomised control trials.

Three prominent texts (Kumar et al., 2007; Levy et al., 2009; White, 2006) have been included to provide background information regarding cannulation technique and findings. Two key educational articles indexed (Ball, 2006; McCann et al., 2009) were not included in the literature review, but provided relevant background information to the findings. International and Australian HD guidelines were considered along with current HD data as per the Australia and New Zealand Dialysis and Transplant Registry to ensure currency and relevance of the literature review (CARI, 2004; KDOQI, 2011; McDonald et al., 2011).

Findings
Following analysis of the papers selected for review, five themes consistently emerged in regard to implementation of buttonhole cannulation:

- Increased infection rates.
- Reduced pain reported by the patient, resulting in less local anaesthetic use.
- Decreased aneurysm development.
- Minimal infiltration rates resulting in reduced incidence of haematoma formation.
- Shortened time required to achieve haemostasis.

Increased infection rates
Infections of native AVFs are considered rare and must be taken seriously in the dialysis-dependent population due to impaired immunologic status. They are most commonly caused by inattention to aseptic technique during cannulation and require immediate antibiotic treatment (Doss et al., 2008; KDOQI, 2011). Birchenough et al. (2010) and Nesrallah et al. (2010) recognise infection to be a major cause of death of patients on dialysis. Staphylococcus aureus, bacteria which regularly colonises skin and nasal passages, is most commonly identified. Infection is listed as the third most frequently reported cause of death for dialysis-dependent individuals in Australia and New Zealand (McDonald et al., 2011).

Interestingly, of the 16 papers reviewed, 10 or 62.5% cited an increased risk of localised infection secondary to buttonhole cannulation (Castro et al., 2010; Chow et al., 2011; Doss et al.,
Inadequate skin preparation may result in localised infection or bacteraemia, with significant consequences in the HD population. Meticulous skin preparation prior to cannulation of the AVF is crucial to risk reduction (Labriola et al., 2011). Effective scab removal with a sterile instrument post-skin cleansing prior to cannulation is critical as the use of contaminated instruments during scab removal may introduce bacteria into the site or bloodstream (Van Eps et al., 2010). Following complete scab removal, a second skin preparation is required to ensure complete scab particle removal, thereby further reducing risk of bacteraemia (Labriola et al., 2011). Chow et al. (2011) recognised omission of a second skin preparation throughout the study period, which may have resulted in elevated infection rates. Under busy work schedules and with limited time to cannulate, staff may become lax and use inadequate skin preparation, or fail to completely remove scabs (Doss et al., 2008; Labriola et al., 2011). Inappropriate application of the disinfection protocol by nursing staff or self-cannulating patients was highlighted by van Loon et al. (2009) and Doss et al. (2008) as a likely cause of increased infection rates. Staff re-education regarding cleansing technique and scab removal resulted in a reduction of infection rates (Birchenough et al., 2010; Labriola et al., 2011). Lapses in skin preparation were reported by several participants during research conducted by Chow et al. (2011) which may have influenced the results. Doss (2008) recognised a similar pattern, perhaps due to overall ease of cannulation, when compared with the rope-ladder technique. Individuals who self-cannulate may become familiar with regular cannulation, resulting in a more casual attitude and less care in preparation, as recognised by Birchenough et al. (2010), resulting in greater infection risk.

Further consideration should be given to research conducted by Van Eps et al. (2010) who observed a cohort of HD-dependent individuals commencing nocturnal home HD following an extensive education programme. Previously all had been attending standard in-centre HD sessions three times per week, using the rope-ladder technique. Participants utilised the buttonhole technique to access their AVF at home. The control group continued with conventional in-centre HD, utilising the rope-ladder technique. Van Eps et al. (2010) reported an increase in septic events within the nocturnal home dialysis group, and suggested this may be related to the combination of nocturnal home HD and use of the buttonhole cannulation technique. Similarly, Nesrallah et al. (2010) also studied a cohort of nocturnal home HD patients. The researchers proposed the combination of increased cannulation frequency, longer dialysis time and self-cannulation contributed to increased infection rates. Topical Mupirocin prophylaxis may reduce the risk of infection attributed to buttonhole cannulation (Birchenough et al., 2010; Nesrallah et al., 2010).

It is imperative dialysis units electing to use buttonhole cannulation enforce rigorous skin cleaning and scab removal protocols, to be followed by staff and self-cannulators alike. Aseptic technique must be maintained to reduce risk of infection (Doss et al., 2008; Ludlow, 2010; Nesrallah et al., 2010).

### Pain perception

Patients undergoing HD often report pain during AVF cannulation. Repeated cannulation, as required for continuing HD, may result in considerable pain and ongoing anxiety due to the calibre and bevel length of the dialysis needle (Figueiredo et al., 2008). Research indicates the buttonhole technique reduces cannulation pain, thereby reducing the patient’s fear of cannulation and subsequent use of local anaesthetic, the use of which has been associated with vasoconstriction (Ball, 2006). One observational study reviewed selected individuals who regularly experience severe cannulation pain to participate in buttonhole cannulation. Pain intensity during buttonhole cannulation was reported as minimal or none, as opposed to severe during rope-ladder cannulation, thus confirming that the buttonhole technique reduces cannulation pain (Silva et al., 2010). In contrast, van Loon et al. (2010) reported higher pain and anxiety scores in the buttonhole cohort although less local anaesthetic was used when compared to the rope ladder group. This inconsistency with other research papers may be because van Loon et al. (2010) compared pain sensation of both techniques in the same patient, unlike most other studies. Pain is subjective and can only be assessed by the individual experiencing it, which may result in inconsistencies between different study results (Figueiredo et al., 2008).

Despite no reduction in pain scores, local anaesthetic use was reduced or ceased within six months of changing to buttonhole cannulation, most commonly after the introduction of blunt needles. Participants initially were reluctant to reduce or cease local anaesthetic use as they were fearful of experiencing increased pain even after initiation of dull needles (Chow et al., 2011; Doss et al., 2008; Strutters et al., 2010).

Hashmi et al. (2010) did not discuss the use of local anaesthetic, but noted study participants reported reduced pain levels following implementation of the buttonhole technique, as did Castro et al. (2010) and Ludlow (2010). Participants stated they preferred the buttonhole technique, many stating they would recommend it to fellow patients over the rope-ladder technique (Ball et al., 2007; Castro et al., 2010; Hashmi et al., 2010; Strutters et al., 2010).
One descriptive prospective study focused on pain perception in association with AVF cannulation. Researchers compared the rope-ladder technique with buttonhole cannulation, reporting a reduction in pain perception when using the buttonhole technique (Figueiredo et al., 2008). This reduction was not statistically significant, although patients reported greater satisfaction with the buttonhole technique (Figueiredo et al., 2008). Conversely, Chow et al. (2011) and Struthers et al. (2010) measured no difference in pain perception between participants undergoing buttonhole or rope-ladder cannulation. Likewise Verhallen et al. (2007) reported no decline in cannulation pain, whereas Ball et al. (2007) noted 70% of participants reported pain reduction. It must be acknowledged that Figueiredo et al. (2008) did not discuss the use of local anaesthetics, unlike many other studies reporting on pain perception during cannulation.

The buttonhole technique may reduce pain of cannulation and aid individuals who have needle phobias. The majority of patients state they experience less pain with buttonhole cannulation when compared to rope laddering, many of whom also feel less anxious (Figueiredo et al., 2008; Hartig & Smyth, 2009; Ludlow, 2010). Pain with cannulation is an important quality of life indicator for dialysis-dependent individuals; therefore, pain reduction with buttonhole cannulation may be a positive outcome for all HD-dependent patients who experience even mild cannulation pain, and to reduce the use of local anaesthetics (Ludlow, 2010; Struthers et al., 2010).

Aneurysm development

Research indicates AVF aneurysms, or localised dilatations, are most often caused by stenosis, resulting in back pressure causing vessel distension and subsequent weakening of the vessel wall and thinning of overlying skin (Kumar et al., 2007). Cannulation technique may also result in aneurysm formation. Frequent cannulation in the same area, as with “area puncture” or poor “rope laddering” technique, damages the vessel wall and may lead to aneurysm development and stenosis formation. Aneurysms and associated stenosis result in blood recirculation during HD and eventual thrombosis of the AVF (Ball et al., 2007; Birchenough et al., 2010). Puncture of the aneurysm should be avoided as skin integrity is compromised. Damage from cannulation or accidental trauma may result in rupture and significant haemorrhage (Levy et al., 2009).

The buttonhole technique significantly reduces the risk of aneurysm formation secondary to cannulation and existing aneurysms may significantly reduce in size (Ball et al., 2007; Hashmi et al., 2010; Struthers et al., 2010; van Loon et al., 2010; Verhallen et al., 2007). One HD unit in Ball et al.’s (2007) study commenced buttonhole cannulation for patients with existing aneurysms to prevent enlargement and reduce risk of further complications. Tracks were formed in areas of maximal skin integrity avoiding the aneurysm, resulting in reduced AVF dilatation, thereby increasing AVF life and reducing associated complications (Ball et al., 2007; Verhallen et al., 2007).

Consideration must be given to the fact that all papers considered for this review noted limitations in study time frame and participant numbers. All studies were less than five years’ duration. Aneurysm development may not be evident for a number of years. Early results suggest buttonhole cannulation reduces the risk of aneurysm formation. Longitudinal studies with greater subject numbers are recommended to ascertain risk in long-term HD patients.

Needle infiltration and haematoma development

An infiltration or “blow” means the needle has pierced the side wall or base of the AVF during cannulation or following commencement of dialysis. It causes blood to leak into surrounding tissues, causing pain and swelling. Re-cannulation is often necessary. The most common reason for infiltration is poor cannulation technique (KDOQI, 2011). Buttonhole cannulation has been associated with reduced incidence of infiltration and haematoma, which is known to reduce AVF survival and increase morbidity (Ball, 2006; van Loon et al., 2010; Verhallen et al., 2007). Cannulation when creating buttonhole tracks should be performed by skilful HD nurses with experience in buttonhole cannulation. The track should be developed, over 8–12 cannulations, by a single cannulator using a sharp needle. Following track formation, blunt needles should be used, and other cannulators, including self-cannulators, may access the AVF by following the track exactly as it was formed (Ball, 2006; Ludlow, 2010). The blunt needle glides into a well-formed buttonhole track with little resistance. Additionally, the use of blunt needles reduces the risk of damage to the fibrous track and may minimise tissue injury should miss-cannulation occur. Gentle pressure only should be used when cannulating with a blunt needle. Applying force may damage the vessel wall or the tunnel track resulting in infiltration or haematoma (Ball et al., 2007; Ludlow, 2010).

Miss-cannulation may result in infiltration and subsequent haematoma. Establishment of a fibrous needle track as seen in buttonhole cannulation reduces the risk of infiltration and haematoma formation. The use of blunt needles further reduces this risk (Silva et al., 2010; Struthers et al., 2010). Hartig and Smyth (2009) stated 87% of participants using the buttonhole technique denied infiltrations during the study period. Hashmi et al. (2010) and Ball et al. (2007) also reported statistically significant decreases in needle infiltrations when comparing buttonhole cannulation to the rope-ladder technique.

Conversely, Ludlow (2010) noted an increase in needle infiltrations during the study period, although participants reported a reduction in haematoma formation. Incidence became less frequent as time progressed, and tracks became well established. Interestingly, van Loon et al. (2009) also reported more miss-cannulations, but reduced haematoma formation. During buttonhole track development patients may experience miss-cannulations and needle infiltrations, resulting in haematoma, particularly with multiple cannulators or if the cannulator is inexperienced in the buttonhole technique or
AVF cannulation (van Loon et al., 2010; Verhallen et al., 2007). Participants in Ludlow’s (2010) and van Loon et al.’s (2009) research were new to buttonholing whereas the majority of individuals utilising the buttonhole technique in Hashmi et al.’s (2010) study had been doing so for over a year.

Castro et al. (2010) and Verhallen et al. (2007) did not discuss infiltration, but reported fewer incidences of haematoma formation when comparing buttonhole cannulation with rope ladder. In contrast, Chow et al. (2011) report an increase in haematoma formation at the cannulation site. The authors consider this to be due to nursing staff’s unfamiliarity with the buttonhole technique, which was introduced for the study following education and training.

**Shortened time required to achieve haemostasis**

Time to achieve haemostasis, or compression time, is variable and dependent on anticoagulant dosing and individual AVF characteristics. Increased compression time may result in thrombosis, re-bleeding or stenosis formation, consequently loss of the AVF may occur (Ball, 2006). Generally 5–10 minutes of mild pressure over the cannulation site post-needle removal is required. The use of blunt needles causes less tissue damage, resulting in shorter time to achieve haemostasis and reduced risk of re-bleeding and associated complications (Ball et al., 2007; Hartig & Smyth, 2009; Hashmi et al., 2010; Ludlow, 2010).

Interestingly, Ludlow (2010) noted a reduced time to achieve haemostasis, but it was not statistically significant, whereas Verhallen (2007) did not report any difference in time to achieve haemostasis, or incidence of re-bleeding. Some researchers expected increased time to achieve haemostasis and a greater risk of re-bleeding due to constant puncture at the same site and permanent track formation. This was not observed in papers reviewed (Ball et al., 2007; Hartig & Smyth, 2009; Hashmi et al., 2010).

**Discussion**

Buttonhole cannulation requires a different technique to rope-ladder cannulation. Rope ladder allows for individual differences in site selection, needle direction and angle (Birchenough et al., 2010; Silva et al., 2010). In contrast, with buttonhole cannulation site location, needle direction and angle of insertion are determined by the original cannulator, and must be followed exactly. Inappropriate force or cannulation technique which does not mimic the original cannulator may result in trauma and subsequent complication. The use of one individual to create and establish the buttonhole track results in a well-formed track, minimising the risk of subsequent complications (Castro et al., 2010; Hashmi et al., 2010; Silva et al., 2010). This may pose challenges as, in reality, staff work varied shifts and the initial cannulator may not be able to complete track formation, which may take several weeks (Hartig & Smyth, 2009; Ludlow, 2010; Struthers et al., 2010). Following transition to blunt needles, a single cannulator is no longer required. Subsequent cannulators should only use blunt needles and must follow the direction and angle of the developed track (Ludlow, 2010; Verhallen et al., 2007).

Effective buttonhole cannulation requires complete alignment of the fibrous track and formed vessel flap. Alignment may not occur due to increased vascular volume, extended break between dialysis sessions or slight variations in cannulation technique, making it difficult for the cannulator to insert a blunt needle (Ball et al., 2007). When resistance occurs during cannulation, the blunt needle should be partially withdrawn and reinserted at the correct angle (Ludlow, 2010). A sharp needle should not be used as it results in damage to the track, and may pierce the vessel wall in a different area, causing trauma and consequently increasing risk of complications including pain, aneurysm, infiltration, haematoma and delayed haemostasis (Ball et al., 2007; Verhallen et al., 2007). Risk of infection is increased due to formation of false tracks when sharp needles continue to be used in well-formed tracks (Birchenough et al., 2010; Labriola et al., 2011). The use of blunt needles maintains the established track, minimises vessel trauma and may extend access life (Ball et al., 2007; Hashmi et al., 2010; van Loon et al., 2010; Verhallen et al., 2007). Many advantages of the buttonhole technique may be attributed to the use of blunt needles (Castro et al., 2010; Hartig & Smyth, 2009).

The benefits of the buttonhole technique may be overshadowed by an increase in infective complications. Strict cleansing, scab removal and cannulation protocols, together with prophylactic topical antimicrobial use may minimise bacteraemia and localised infections (Labriola et al., 2011; Nesrallah et al., 2010). Ongoing assessment and education with frequent monitoring and evaluation may prevent HD staff and patient from becoming lax (Doss et al., 2008; Labriola et al., 2011). Interestingly, despite almost two thirds of the papers reviewed citing increased infective rates to be a complication of buttonhole cannulation, only one reported statistical significance (Castro et al., 2010; Chow et al., 2011; Doss et al., 2008; Labriola et al., 2011; Ludlow, 2010; Nesrallah et al., 2010; Silva et al., 2010; Van Eps et al., 2010; van Loon et al., 2010; Verhallen et al., 2007).

It must also be noted that of the five areas discussed, a reduced incidence of infiltration and haematoma formation consistently reached statistical significance (Ball et al., 2007; Hartig & Smyth, 2009; Hashmi et al., 2010; Ludlow, 2010). A result is considered statistically significant if occurrence is unlikely to be caused by chance. The themes discussed, although not necessarily statistically significant are clinically meaningful and must be given due consideration. Many of the studies have small population sizes which limit the reliability of statistical tests applied (Castro et al., 2010; Chow et al., 2011; Figueiredo et al., 2008; Hartig & Smyth, 2009; Hashmi et al., 2010; Ludlow, 2010; Nesrallah et al., 2010; Silva et al., 2010; Struthers et al., 2010; Verhallen et al., 2007). Qualitative research examining the patient perspective may be warranted, especially when considering many of the papers reviewed cited patient preference for buttonhole cannulation (Ball et al., 2007; Castro et al., 2010; Hashmi et al., 2010; Ludlow, 2010; Silva et al., 2010; Struthers et al., 2010; van Loon et al., 2010; Verhallen et al., 2007).
Conclusion

Review of the current literature highlighted a number of potential benefits in cannulating a native AVF utilising the buttonhole technique when compared to rope laddering, particularly if the AVF is fragile, has a limited area available for cannulation or is challenging to cannulate. The use of blunt needles following establishment of the buttonhole track reduced the incidence of missed cannulations, infiltration and subsequent haematoma formation. Reduction in potential complications associated with AVF cannulation results in decreased cannulation time, increased ease of cannulation and reduced need for intervention. Many patients preferred the buttonhole technique due to reduced pain associated with needling and ease of cannulation once the track has been established. They are less anxious, more willing and able to self-cannulate, resulting in greater independence and improved quality of life.

The incidence of infection cannot be ignored when considering buttonhole cannulation. Meticulous skin preparation together with careful attention to scab removal prior to cannulation with an aseptic technique is paramount. Appropriate technique, using blunt needles and gentle pressure is vital if using the buttonhole technique to reduce risk of damage to the fibrous track. Careful consideration of individual AVF and patient characteristics, patient preference and primary cannulator is required when choosing the most appropriate cannulation method. Cannulator inexperience may result in access complication regardless of technique adopted. Further longitudinal research with larger participant numbers is required to provide further information regarding the long-term effects of buttonhole cannulation in comparison to the rope-ladder technique.

References


