Buttonhole cannulation of arteriovenous fistulas in the United States

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Abstract

The cannulation technique of a hemodialysis vascular access has remained controversial with differing viewpoints. The quality of dialysis, overall patient safety and individual dialysis experience often dictate the type of cannulation technique used in clinical practice. The three commonly used techniques to access a hemodialysis vascular access are the rope-ladder, area and buttonhole. Even though the buttonhole technique has been around since mid-1970's, the dialysis community remains divided on its suitability for routine use to provide maintenance hemodialysis therapy. The proponents of this technique value the ease of cannulation with less pain and discomfort while the opponents highlight the increased risk of infection. The actual clinical evidence from the United States is limited and remains inconclusive. The current review provides an overview of the available experience from the United States, highlighting the correct technique of creating a buttonhole, summarizing the current evidence and recommending a need for larger randomized controlled studies in both in-center and home hemodialysis population.
**History of buttonhole cannulation technique:**

A well-functioning vascular access is essential to provide adequate maintenance hemodialysis. Once the initial barriers to creating an arteriovenous fistula (AVF) are crossed, its long-term patency depends on regular monitoring for signs of dysfunction with timely intervention, proper cannulation technique, and minimizing common complications such as thrombosis, infection and aneurysm formation. Additionally, patient factors such as pain during cannulation and aesthetics often dictate the selection of a cannulation technique. The three frequently used cannulation techniques in clinical practice are described as ‘rope-ladder’ (RL), ‘area’ and ‘buttonhole’ (BH). The RL or different site technique involves sequentially using a different site to place two needles during consecutive dialysis sessions. In area or cluster technique, the needles are placed in the same area while with BH or ‘constant site’ technique the needles are placed at a constant site through a subcutaneous tunnel/tract at consecutive dialysis treatments (Figure 1).

The BH technique was first described in the Polish literature in 1977 as a “constant site” method and was used serendipitously for a patient who had a short cannulation segment (1, 2, 3). The method was observed to be less painful by the patient leading to a first publication of experience with 16 cases in 1979 (4). Subsequently, comparing constant site to standard method in 10,000 dialysis sessions, positive patient experiences such as easy and quick cannulation, less pain and 10-fold reduced hematoma formation were observed. In 1984, Kronung coined the term “buttonhole puncture” for constant site technique (5).
The use of blunt needles instead of sharp beveled needles also resulted as a pure coincidence. In the past, the needles were reused routinely leading to blunting of the sharp edge. The dull needles were found to cause minimal trauma to the established subcutaneous tract during cannulation (2).

**Early experiences and enthusiasm:**

There is a paucity of data detailing the use of the BH cannulation in the United States. The groups from Washington and Oregon were pioneers in adopting this technique, which gradually spread to a few centers across the country (6). The BH method was often considered in patients with short cannulation segments, and self-cannulating patients. Early enthusiasm with using this technique was mainly due to the potential advantages identified in the earlier reports from Poland (1, 4). About 38% of the centers from the region were utilizing the buttonhole technique (7). In one facility, buttonhole cannulation reduced the infiltration rate from 7% to 0% and decreased hemostasis time from 8 minutes to 5 minutes as compared to the RL method, without any increase in infection rates, need for angioplasty intervention or observable aneurysm formation at the cannulation sites. A patient satisfaction survey reported that 100% of the patients using BH method felt decreased discomfort and pain compared to RL method with sharp needles. The staff members expressed satisfaction as using blunt needles reduced the risk of needle stick injury (7).

Another survey from the same region sent to all 61 patients using BH technique, had a 75% response rate with 70% experiencing less pain and 20% equivocal as compared to
RL technique. Furthermore, 63% felt that it took less time to insert buttonhole needles as compared to conventional needles. Overall, patients reported that their arms looked better, scabs were smaller with faster healing. The researchers also found that there was a substantial decrease in infections, missed sticks and infiltrations.

**Buttonhole technique:**

**Indications-**

Buttonhole cannulation is usually selected for AVFs with a short cannulation segment or because of patient preference. Buttonhole creation and cannulation can be accomplished by the patient or nurse in the in-center hemodialysis (HD) unit and by the patient or caregiver with home hemodialysis (HHD) (8). (Figures 3 and 4, List 1).

**Steps for buttonhole creation-**

1. **Goal:** The goal of buttonhole cannulation is to develop two fibrous tracts from the skin surface into the AVF that can be repeatedly cannulated with blunt needles.

2. **Choosing the BH sites:** A straight segment of the AVF is selected for cannulation. Curves, flat spots and aneurysms of the AVF are avoided. The arterial needle cannulation site is usually located few inches proximal to the arterial anastomosis of the AVF. The needle entry sites are spaced at least 2-3 inches apart.

3. **Cannulating with sharp needles to create BH:** The cannulator should wear a facemask as it prevents the spread of bacteria during the disinfection and cannulation steps. Both hands of the cannulator and the access site are thoroughly cleaned with antibacterial soap. The access extremity is positioned comfortably, lighting should be good and glasses worn if needed. A tourniquet is
placed over the AVF above the cannulation site to enlarge the AVF. The direction
of the needle and choice of the buttonhole site is dictated by the patient in the
self-cannulation method. The needle tip is aligned over the cannulation site with
the bevel up. The skin puncture site should be at a distance of 3-5 mm from the
AVF creating a short subcutaneous tunnel (Figure 1 and 2). The skin over the
AVF is pulled side ways to make it taut and the AVF is cannulated at an angle
appropriate for the depth of the vein (usually 20-25°). When a flash back is
observed, the insertion angle is lowered and the needle is slowly advanced. The
needle is never inserted so far that the hub of the needle is touching the insertion
site.

4. Subsequent cannulations with sharp and blunt needles: A face mask is worn and
the access site and hands are cleaned as described above. Scabs are removed
from the buttonholes (described in the next section) followed by repeat
disinfection of the access sites prior to needle insertion. Sharp needles are
introduced at the two selected sites, at the same angle, in the same direction and
at the same depth with each cannulation by the same cannulator for
approximately 6-10 cannulations until the fibrous tracts are formed. Cannulation
with blunt needles is then attempted through the BH sites by the same
cannulator.

5. Disinfection and scab removal: Disinfection of the skin and BH sites is a very
important step to prevent infections (9). BH sites are disinfected with an
approved disinfecting agent, such as 2% chlorhexidine gluconate / 70 %
isopropyl alcohol, betadine/povidone iodine, 70% alcohol, sodium hypochlorite,
(follow manufacturers recommendations on contact time). Enough time should be allowed for the scab to soak and soften for easy removal. A different swab is used to disinfect each site. Following disinfection, it is important that scabs in the BH are removed. Scabs are formed from blood entering the fibrous tract after needles are removed. Scabs can be colonized by skin flora such as Staphylococcus aureus, and cause blood stream infections if not removed. If the scabs are not dislodged during the initial disinfection process, they should be further softened with a gauze soaked in saline, water or antibacterial soap or an alcohol pad. To loosen the scabs, the skin is stretched in all four directions around each site and scabs are removed completely using a sterile gauze or scab removal device (comes with blunt needles). The scab removal device is inserted at the edge of each scab and the scab is dislodged. Others have described non-invasive methods of scab removal using a shower scrubber or an exfoliating facial sponge and antibacterial soap for scab removal (10). Needles should not be used to remove the scab as sharp needles could cut into the skin and cause infection or oozing. After scab removal, the BH sites should be disinfected again as the scab harbor bacteria, which may spread during the scab removal process. Topical anesthetics and subcutaneous lidocaine to numb the area before the cannulation procedure should be avoided. The use of these products may cause scarring, vasoconstriction and keloid formation making needle insertion more difficult.

6. Buttonhole site care post-cannulation: Calcium mupirocin 2% ointment can be applied directly to BH and allowed to dry with no bandage after needle removal.
and has been shown to decrease infections (11). Applying a polysporin or betadine gauze pad over the buttonhole sites for a minimum of six hours after needle removal has also been shown to reduce infections (12).

Techniques to form predictable BH

Toma et al (13) have described a time-saving method to create a buttonhole tract using thumbtack-shaped polycarbonate peg (BioHole™ Plug) that is inserted into the access vessel along the same path as the puncture needle that has just been removed. Then, at the beginning of the next HD, the peg is removed and a blunt puncture needle is inserted along the track already formed by the peg left in place. This buttonhole puncture approach was used by Toma in 37 patients for 3 months, no significant bleeding was noted during HD and only one patient had enough erythema at the puncture site to suggest possible infection.

Marticorena has described the use of Supercath Clampcath SP 502® hemodialysis needle combined with an overlying polyurethane catheter left indwelling after dialysis for 10 days in 12 patients (14). The hemodialysis needles were 17G, 1 in. long Clampcath SP 502® (Togo Medikit Co. Ltd., Miyazaki, Japan). The Clampcath® catheters were inserted as arterial and venous needles for the first dialysis, at selected sites. The needles were removed and the polyurethane catheters were secured with Steri-Strips® (3M Health Care, St. Paul, MN, USA) and the skin entry site was covered with a 2 × 2 sterile gauze with Polysporin® (Pfizer Canada Inc., Markham, ON, Canada) antibacterial ointment and covered with Tegaderm® (3M Health Care) dressing. Post-
dialysis, the catheters were flushed with 10mL of normal saline and then 0.6 mL of citrate 4% was instilled into each lumen. At the end of the dialysis performed on the 10th day, both polyurethane catheters were removed. Blunt needles were used for the next dialysis treatment using all the antiseptic precautions. Successful buttonholes were created in 11 of 12 patients after 10 days. Pain scores for the first blunt needle cannulation with this technique was significantly less than with the classical technique. Following this report, two cases of fracture and dislodgement of the Supercath Clampcath when used for making buttonholes have been described, raising concerns for the safety of this technique (15,16).

Data from US centers

One of the first U.S. experiences with BH use was published by Ball et al in 2007, from 4 in-center HD facilities located in Washington and Oregon (7). In one HD center, which compared BH use (N=25) to rope-ladder (RL) (N=17), there was no difference in access infection or in interventions for stenosis/thrombosis between the groups. Access infiltrations and time to hemostasis were lower in the BH group. No aneurysms formed in the BH group. In the second HD center, access infections and infiltrations were lower using BH compared to RL, as self-reported by a patient survey (N=61). In the remaining two HD centers (BH patients: N=13, and N=14), access infections occurred in 8% and 21% of AVFs using the BH technique. However, no comparator data for concurrent RL complications was provided from these 2 units. Unfortunately, in this publication the duration of patient follow-up was not provided, and measured outcomes and definitions were not standardized among HD facilities.
In 2010, Birchenough et al. reported a markedly higher rate of access infection using BH technique in a single-center report from a HD facility in New York (17). Data from both in-center and home hemodialysis (HHD) patients was collected retrospectively over a 13-month period prior to the implementation of a quality improvement project. In this initial period, access infection occurred in 52% patients using the BH and 5% using RL. After a revised BH policy and procedure was introduced, there was a reduction in access infection associated with BH to 30% in a 14-month follow-up period. No infection data were provided for the RL technique in this post-quality improvement period. Data about other complications such as aneurysm, access interventions and access infiltration was not provided, nor was the definition of access infection and or data about the total number of BH and RL patients.

In 2014, Chan et al compared complications over a 1-year period associated with the BH and RL techniques from a single center in Wisconsin, using a prospectively collected database (18). Patient demographic and clinical characteristics were similar between the BH (n=45) and RL (n=38) groups, with the exception of diabetes mellitus, which was more prevalent in the BH group (69% vs. 34%, p=0.002). There were similar bacteremia rates (BH 11% vs. RL 8%, p=0.62) between the techniques. Bacteremia was defined as at least 1 positive blood culture with definite or probable association with infection secondary to the AVF. No data were provided for local access infections. In a multivariate analysis, there was similar primary patency at 3, 6, and 12
months (HR=1.22, (95% CI, 0.65-2.28; p=0.53), and similar number of access interventions (BH 64% vs. RL 71%. p=0.52).

A low incidence of access infection with BH cannulation was reported in a small single-center, retrospective study in a pediatric in-center dialysis population in Missouri (19). In 2019, Moore et al retrospectively reviewed data in 14 patients using BH technique over 11 years. Mean follow-up was 15 months (range 3-58 months). There was only 1 local access infection with Staphylococcus aureus. No other outcomes were reported.

In contrast, Lyman et al (20) reported a significantly higher risk of vascular-access related infections associated with BH cannulation in U.S. patients on hemodialysis treated in the outpatient dialysis centers (5). A retrospective observational study was performed using data from the National Healthcare Safety Network (NHSN) surveillance report from 2013-2014. In 2014, 9% (n=271,980) of all AVF patient-months reported to NHSN were among BH patients. During the study period, there were 2,466 access-related blood stream infections, 3,169 local access site infections and 13,726 intravenous antimicrobial initiation in HD patients using the BH cannulation technique. Hospitalization occurred in 37% of patients with access-related blood stream infections. After adjusting for facility characteristics and practices, buttonhole cannulation was associated with significantly higher risk of access-related bloodstream infection (aRR=2.6, 95% CI=2.4-2.8) and local access site infection (aRR=1.5, 95% CI=1.4-1.6), but was not associated with increased risk of intravenous antimicrobial start.
The available U.S. data, albeit limited, favor a reduced risk of aneurysm formation using BH technique. The initial studies from centers in the Pacific Northwest in 2007 reported no aneurysms with BH use (7). In 2011, Pergolotti et al reported a lower rate of aneurysm formation using the BH technique (21). This study included 45 patients (21 using BH and 24 using RL technique) who were dialyzing at an in-center HD facility in New York, and who were followed over a 4-month period. Aneurysms were observed in 20% of patients using the BH technique and 46% using the RL method. The authors state that preexisting AVF aneurysms were present before BH technique was initiated in this group, therefore overestimating the incidence of aneurysm formation attributable to BH.

**Data from centers outside US**

The experience from non-US centers has been very different. In 2014, MacRae et al in a randomized controlled trial with 140 patients reported no difference in AVF survival (RR=1.04; 95% CI 0.81, 1.34) and no difference in pain between buttonhole and rope ladder cannulation technique. The risk of serious AVF related Staphylococcus aureus bacteremia was significantly higher with buttonhole compared to rope ladder method at 1-year, (13% vs. 0% respectively; RR=19; 95% CI: 8, 46) (24). Muir et al reviewed 90 consecutive home hemodialysis patients trained in buttonhole cannulation method. The total AVF infection rate was higher with the use of buttonhole method (incidence ratio 3.85; CI 1.66, 12.77; p=0.03). Additionally, a systematic review of 4 randomized and 7 observational trials, the authors found AVF related infections to be increased with buttonhole method compared to rope ladder method. (RR 3.3; 95% CI 0.91, 12.20) (26).
Patient satisfaction, pain with cannulation, need for surgical or endovascular intervention was statistically not different between BH and RL.

**Perspectives from the front lines**

The 2020 Vascular Access Guidelines from the National Kidney Foundation Kidney Disease Outcome Quality Initiative considers it reasonable to limit BH only to special circumstances given the associated increased risks of infection and related adverse consequences. Moreover, BH cannulation refers only to AVF. Arteriovenous grafts should not be accessed by BH cannulation due to risk of pseudoaneurysm and “one-siteitis” (22). The guideline was justified based on international data analyzed from several randomized control trials and observational studies comparing BH versus RL cannulation technique (23 -26).

The issue of whether the renal community should support or discourage the use of buttonhole cannulation is highly dependent on the vantage point of the party involved (27-29). Patients may rate their experiences with BH technique favorably compared to RL technique, with reduced pain, compression time, oozing, re-bleeding, and ease of use (24). Fear of pain and discomfort (needle phobia) is a widely-accepted barrier to self-cannulation by patients, and by extension, ability of patients to be trained to perform HHD (28). The preponderance of currently available evidence shows an increased risk of infectious complications, leading some experts to advocate strongly against use of BH cannulation from a harm prevention standpoint (29, 30). However, it remains unclear if objective scientific evidence is strong enough to supersede patient autonomy to
choose a riskier, but more personally acceptable option, provided technique and infection control are followed consistently.

Due to the subjective nature of individual life priorities, each informed discussion between clinicians and patients should take into account that the relative weight of outcomes differs between patients, some who may be willing to accept a higher risk of infections in exchange for ease of self-cannulation or less perceived pain or discomfort. What is poorly described are perceptions of practicing nephrologists and advanced practice providers in the community. Recently, Nephrologists Transforming Dialysis Safety Initiative of the American Society of Nephrology (NTDS of ASN) held a focus group session at the American Society of Nephrology Kidney Week 2019 asking if BH cannulation technique should be taught to HHD and in-center HD patients (31). Table 1 lists selected comments. Some expressed a perception that the large dialysis organizations either did not allow or did not recommend BH technique for in-center HD. Other respondents indicated that owing to lack of qualified dialysis staff, patients using BH admitted to the hospital were often switched to sharp needles. An additional concern was that some nephrologists had very little or no experience with HHD and were not as familiar with the infection controversies in buttonhole use.

While the BH data reported by Canada, the United Kingdom and other countries is likely generalizable to the U.S., systemic and cultural health care factors unique to U.S. hemodialysis population may further influence the risk of infection (32, 33). Existing differences between the U.S. and Canada that may impact on BH
outcomes include differences such as patient to nurse staffing ratios, training/education of staff (AVF cannulation by registered nurses versus patient care technicians), hospital-based versus free-standing hemodialysis facilities, local provider expertise in managing self-cannulation issues, and patient selection for HHD. There is a need for future, adequately powered, randomized control trials from U.S. hemodialysis centers, to provide long-term, prospectively collected data and to adequately assess the risk and benefits of BH use in both in-center HD and HHD patients in the U.S.

**Future research needs and potential**

Since staff and patient training and ongoing care for BH cannulation will be strongly influenced by policies and procedures of dialysis providers, future efforts to collect and understand data on practice patterns and outcomes might benefit from a collaborative strategy by stakeholders. The authors of this review contacted five major U.S. dialysis organizations, Fresenius Kidney Care, DaVita, Dialysis Clinic Inc., Satellite Healthcare, and Northwest Kidney Centers, but none of these providers had data specific to BH-related blood stream infections or access-related infections that could be studied versus RL technique. Fresenius reported infection prevention in HHD patients is a major focus, with review of BH cannulation outcomes, dissemination of best practices, and adoption of a centralized access management system are ongoing (*D. Chatoth, personal communication, October 2019*). DaVita is similarly monitoring BH-associated infection rates, has implemented a topical mupirocin prophylaxis protocol, and incorporated mandatory access care technique observation as part of HHD clinic visits (*M. Schreiber, personal communication, October 2019*).
personal communication, October 2019). Hopefully more granular details related to these approaches to buttonhole cannulation will be available as more data is collected.

Summary

In summary, it is difficult to draw firm conclusions about BH risks in the U.S. population based on these limited data. There are no large prospective randomized controlled trials comparing complications using BH to RL technique from U.S. hemodialysis centers. With the exception of the review of the NHSN data (20), most of the available U.S. data on this topic are derived from small, single-center cohorts. The follow-up periods are of relatively short-duration and outcomes not well defined using standard criteria. Most of the existing U.S. data is for patients dialyzing in-center, and minimal evidence exists about the HHD population.
Disclosures

The authors have nothing to disclose.

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| Category                  | Response from focus group participant                                                                                                                                                                                                 |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Patient Selection**    | “It needs to be the right patient at the right time.”                                                                                                                  | “Home patients are more attentive.”                                                                                       |
|                          | “Currently patients who dialyze at home are in the top tier of self-motivation and are currently self-selected. As we increase home dialysis, it will be essential to adapt current practices to allow for more patients who [may not fit these criteria].” |
| **Modality Specific**    | “Fewer patients would be able to choose home if they can’t use buttonholes.”                                                                                             | “Buttonholes should not be created for in-center patients, there is a lot of infection historically, but it’s okay for home patients.” |
|                          | “There should be a checklist for buttonhole cannulation.”                                                                                                               | “Multiple cannulators increase the risk of infection, for example, when there is an in-center creation by clinic staff before the patient is sent home.” |
|                          | “Strict aseptic technique needs to be followed (do not use “scab removers”).”                                                                                             | “NTDS should create a buttonhole registry.”                                                                                   |
| **Best Practices Guidance** | “If NTDS would come up with a position or recommendations on using buttonholes, [we] would go with that.”                                                              |                                                                                                                                 |

Table 1: Nephrologists Transforming Dialysis Safety Focus Group responses from nephrologists and advanced practice providers
List 1 - Summary of key elements for buttonhole cannulation of arteriovenous fistula

1. Ideal patient selection
2. Preferably a single cannulator to create the subcutaneous tract
3. Follow strict asepsis protocol during cannulation and decannulation
4. Use sharp needle only until the subcutaneous tract is created
5. Only use blunt needles for subsequent cannulations
6. Protocolize pre- and post-cannulation steps
Figure 1: Frequently used arteriovenous cannulation techniques
Figure 2: BH-Buttonhole. A – Ideally created BH; B- Absence of subcutaneous track with early signs of infection
Figure 3. Recommended protocol for strict aseptic technique for button hole cannulation (*Nesrallah GE et al. CJASN 5:1047-1053)

1. Wash access with soap and water
2. Perform hand hygiene and use clean gloves
3. Use antiseptic agent and wait for dry time (pre scab removal)
4. Soak scab with alcohol pad for 5 minutes* and gently remove
5. Use antiseptic agent and wait for dry time (post scab removal)
6. Cannulate with sterile blunt needles using aseptic procedure
Figure 4. Recommended protocol for button hole decannulation

*Nesrallah GE et al. CJASN 5:1047-1053. Mupirocin calcium 2% cream

1. Perform hand hygiene and use clean gloves
2. Blunt needle removal using clean gauze to achieve hemostasis
3. Antimicrobial ointment* applied to each buttonhole site
4. No dressings
5. Remove gloves and perform hand hygiene