

# Buttonhole Cannulation of Arteriovenous Fistulas in the United States

Tushar J. Vachharajani<sup>1</sup>,<sup>2</sup> Leslie Wong,<sup>1,2</sup> Vandana D. Niyyar,<sup>3</sup> Kenneth D. Abreo,<sup>4</sup> and Michele H. Mokrzycki<sup>5,6</sup>

## 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. Although the buttonhole technique has been around since the mid-1970s, 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 whereas 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 populations.

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## History of the Buttonhole Cannulation Technique

A well functioning vascular access is essential to provide adequate maintenance hemodialysis (HD). 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 the area or cluster technique, the needles are placed in the same area, whereas with BH or the “constant-site” technique the needles are placed at a constant site through a subcutaneous tunnel/tract at consecutive dialysis treatments (Figures 1 and 2).

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 (1–3). 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 the constant site with the standard method in 10,000 dialysis sessions, positive patient experiences such as easy and quick cannulation,

less pain, and a tenfold reduction in hematoma formation were observed. In 1984, Kronung coined the term “BH puncture” for the constant-site technique (5).

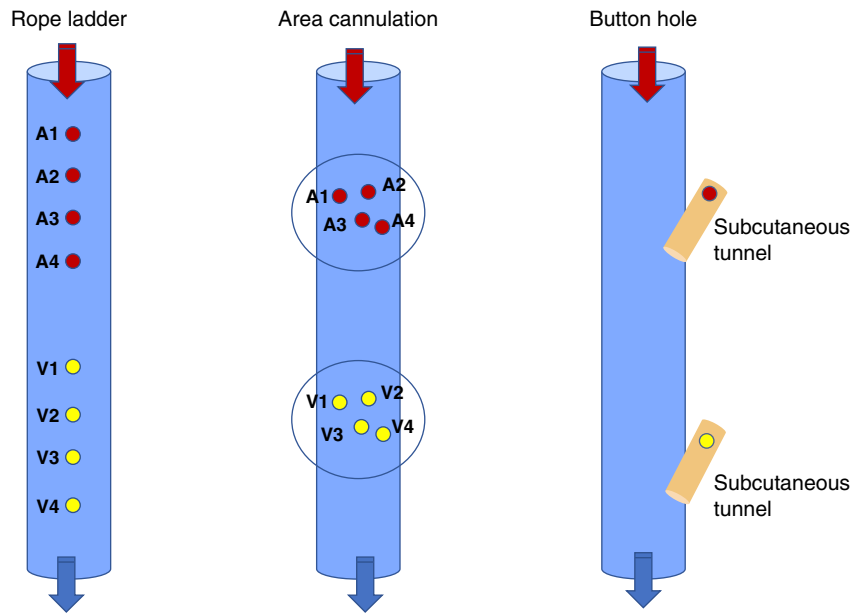
The use of blunt needles instead of sharp, beveled needles also resulted as a pure coincidence. In the past, needles were reused routinely, leading to blunting of the sharp edge. The dull needles were found to cause minimal trauma to the established subcutaneous tract during cannulation (2).

## 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 in 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 using the BH technique (7). In one facility, BH cannulation reduced the infiltration rate from 7% to 0% and decreased hemostasis time from 8 to 5 minutes as compared with 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 the BH method felt decreased

<sup>1</sup>Department of Nephrology and Hypertension, Cleveland Clinic Lerner College of Medicine of Case Western Reserve University, Cleveland, Ohio; <sup>2</sup>Glickman Urological and Kidney Institute, Cleveland Clinic Foundation, Cleveland, Ohio; <sup>3</sup>Division of Nephrology, Department of Medicine, Emory University School of Medicine, Atlanta, Georgia; <sup>4</sup>Division of Nephrology and Hypertension, Department of Medicine, Louisiana State University Health Sciences Center, Shreveport, Louisiana; <sup>5</sup>Division of Nephrology and Hypertension, Department of Medicine, Montefiore Medical Center, Bronx, New York; and <sup>6</sup>Division of Nephrology and Hypertension, Department of Medicine, Albert Einstein College of Medicine, Bronx, New York

**Correspondence:** Dr. Tushar J. Vachharajani, Cleveland Clinic Lerner College of Medicine, Glickman Urological and Kidney Institute, Glickman Tower –Q7, 9500 Euclid Avenue, Cleveland, OH 44195. Email: [vachhat@ccf.org](mailto:vachhat@ccf.org)



**Figure 1.** | Frequently used arteriovenous cannulation techniques. A, arterial site; V, venous site.

discomfort and pain compared with the RL method which involves sharp needles. The staff members expressed satisfaction because using blunt needles reduced the risk of needlestick injury (7).

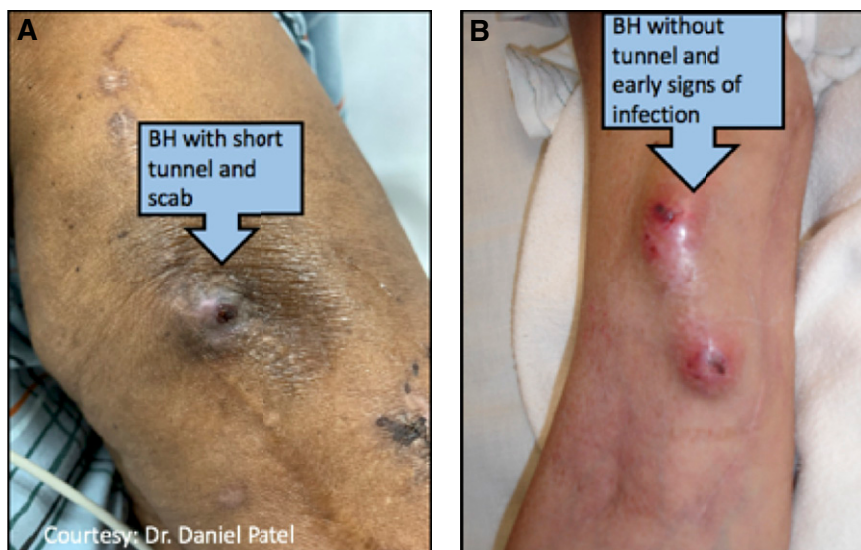
Another survey from the same region sent to all 61 patients using the BH technique had a 75% response rate with 70% of patients experiencing less pain and 20% equivocal as compared with the RL technique. Furthermore, 63% of patients felt that it took less time to insert BH needles as compared with conventional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

a substantial decrease in infections, missed sticks, and infiltrations.

### BH Technique

#### Indications

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



**Figure 2.** | Buttonhole cannulation. (A) An ideally created buttonhole (BH). (B) Absence of subcutaneous track with early signs of infection.

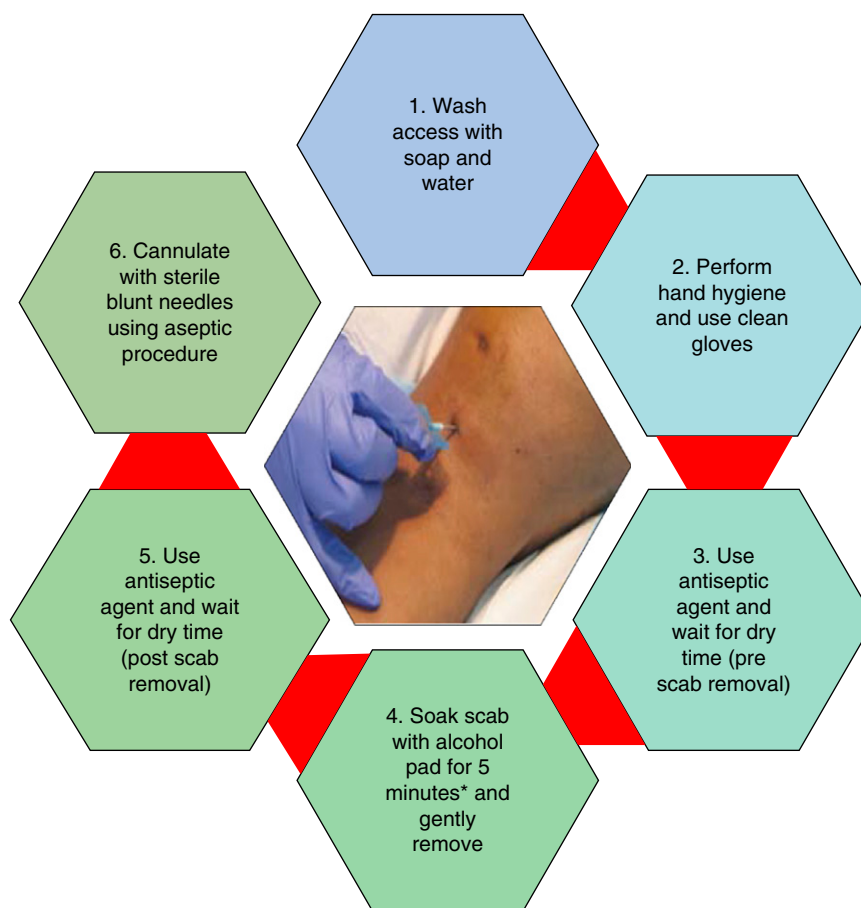
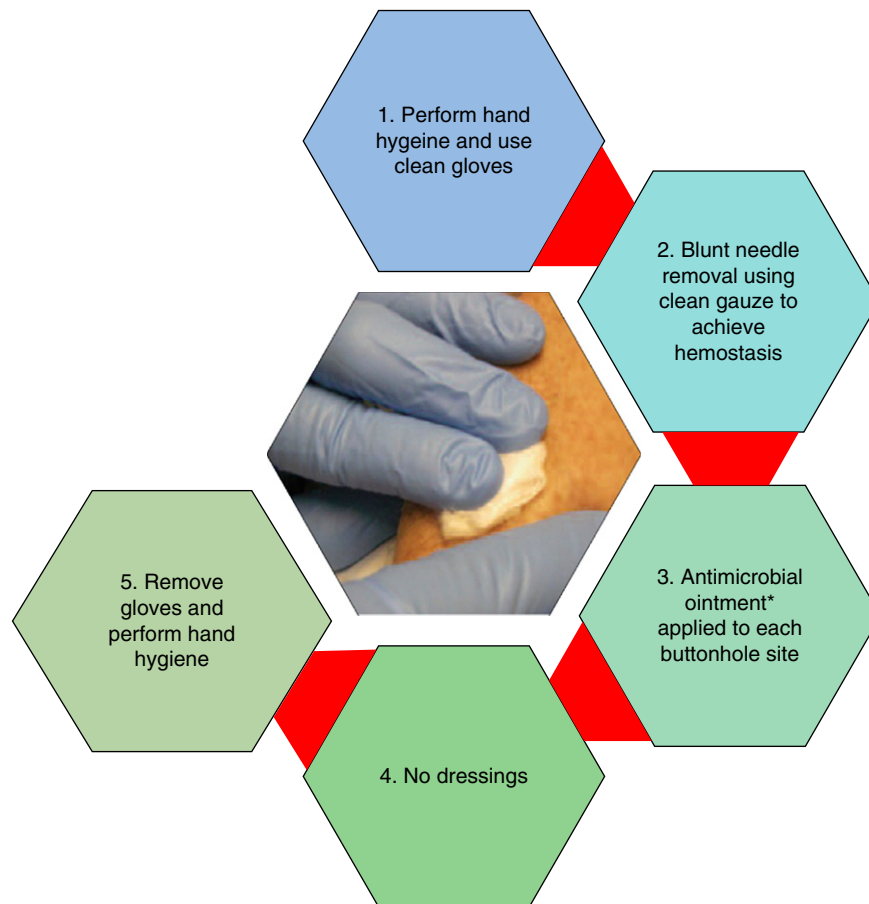


Figure 3. | Protocol for aseptic technique for buttonhole cannulation (recommendation). \*From reference 11.

### Steps for BH Creation

1. **Goal:** The goal of BH 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 a 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 face mask to prevent the spread of bacteria during the disinfection and cannulation steps. Both the 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 should be 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 BH 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 (Figures 1 and 2). The skin over the AVF is pulled sideways to make it taut and the AVF is cannulated at an angle appropriate for the depth of the vein (usually 20°–25°). When a flashback 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 BHs (described in the next section) followed by repeat disinfection of the access sites before 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 six to ten 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, povidone-iodine, 70% alcohol, or 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. After 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*



**Figure 4. | Protocol for aseptic technique for buttonhole decannulation (recommendation).** \*From reference 11, mupirocin calcium 2% cream.

*aureus* and cause bloodstream infections if not removed. If the scabs are not dislodged during the initial disinfection process, they should be further softened with gauze soaked in saline, water, 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 (which comes with blunt needles). The scab-removal device is inserted at the edge of each scab and the scab is dislodged. Others have described noninvasive methods of scab removal using a shower scrubber or an exfoliating facial sponge and antibacterial soap (10). Needles should not be used to remove the scab because sharp needles could cut into the skin and cause infection or oozing. After scab removal, the

BH sites should be disinfected again because the scabs 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. BH site care postcannulation: Mupirocin calcium 2% ointment can be applied directly to the BH and allowed to dry with no bandage after needle removal and has been shown to decrease infections (11). Applying a bacitracin/polymyxin B or povidone-iodine gauze pad over the BH sites for a minimum of 6 hours after needle removal has also been shown to reduce infections (12).

### Box 1. Summary of the 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 postcannulation steps.



### Techniques To Form Predictable BHs

Toma *et al.* (13) have described a time-saving method to create a BH tract using thumbtack-shaped polycarbonate peg 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 BH-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.

Marticoarena (14) has described the use of the Supercath Clampcath SP 502 HD needle combined with an overlying polyurethane catheter, which is left indwelling after dialysis for 10 days in 12 patients. The HD needles were 17 gauge, 1 in. long Clampcath SP 502 needles (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) and the skin entry site was covered with a 2×2 sterile gauze with bacitracin/polymyxin B (Polysporin; Pfizer Canada Inc., Markham, ON, Canada) antibacterial ointment and covered with Tegaderm (3M Health Care) dressing. Postdialysis, the catheters were flushed with 10 ml 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 tenth day, both polyurethane catheters were removed. Blunt needles were used for the next dialysis treatment, using all of the antiseptic precautions. Successful BHs were created in 11 of 12 patients after 10 days. Pain scores for the first blunt needle cannulation with this technique were significantly lower than with the classic technique.

Following this report, two cases of fracture and dislodgement of the Supercath Clampcath when used for making BHs have been described, raising concerns for the safety of this technique (15,16).

### Data from United States Centers

One of the first experiences with BH use in the United States was published by Ball *et al.* (7) in 2007, from four in-center HD facilities located in Washington and Oregon. In one HD center, which compared BH use ( $N=25$ ) with 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 with 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%, respectively, of AVFs using the BH technique. However, no comparator data for concurrent RL complications were provided from these two 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.* (17) reported a markedly higher rate of access infection using the BH technique in a single-center report from an HD facility in New York. Data

from both in-center patients on HD and those on HHD were collected retrospectively over a 13-month period before the implementation of a quality improvement project. In this initial period, access infection occurred in 52% of patients using the BH and in 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 postquality improvement period. Data about other complications such as aneurysm, access interventions, and access infiltration were not provided, nor was the definition of access infection and/or data about the total number of patients using the BH versus RL technique.

In 2014, Chan *et al.* (18) 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. 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% versus 34%,  $P=0.002$ ). There were similar bacteremia rates (11% with BH versus 8% with RL,  $P=0.62$ ) between the techniques. Bacteremia was defined as at least one 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 (hazard ratio, 1.22; 95% CI, 0.65 to 2.28;  $P=0.53$ ) and similar number of access interventions (64% with BH versus 71% with RL;  $P=0.52$ ).

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.* (19) retrospectively reviewed data in 14 patients using the BH technique over 11 years. Mean follow-up was 15 months (range, 3–58 months). There was only one local access infection with *S. 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 United States patients on HD 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 to 2014. In 2014, 9% ( $n=271,980$ ) of all AVF patient-months reported to NHSN were among patients using BH. During the study period, there were 2466 access-related bloodstream infections, 3169 local access site infections, and 13,726 cases of intravenous antimicrobial initiation in patients on HD using the BH cannulation technique. Hospitalization occurred in 37% of patients with access-related bloodstream infections. After adjusting for facility characteristics and practices, BH cannulation was associated with a significantly higher risk of access-related bloodstream infection (adjusted risk ratio [RR], 2.6; 95% CI, 2.4 to 2.8) and local access site infection (adjusted RR, 1.5; 95% CI, 1.4 to 1.6), but was not associated with increased risk of intravenous antimicrobial start.

The available data in the United States, albeit limited, favor a reduced risk of aneurysm formation using the 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.* (21) reported a lower rate of

aneurysm formation using the BH technique. 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 in 46% using the RL method. The authors state that preexisting AVF aneurysms were present before the BH technique was initiated in this group, therefore overestimating the incidence of aneurysm formation attributable to BH.

### Data from Centers outside the United States

The experience from centers outside of the United States has been very different. In 2014, MacRae *et al.* (22) in a randomized controlled trial with 140 patients reported no difference in AVF survival (RR, 1.04; 95% CI, 0.81 to 1.34) and no difference in pain between the BH and RL cannulation technique. The risk of serious AVF-related *S. aureus* bacteremia was significantly higher with the BH compared with RL method at 1 year (13% versus 0%, respectively; RR, 19; 95% CI, 8 to 46) (22). Muir *et al.* (23) reviewed 90 consecutive patients on HHD trained in the BH cannulation method. The total AVF infection rate was higher with the use of BH method (incidence ratio, 3.85; 95% CI, 1.66 to 12.77;  $P=0.03$ ). Additionally, in a systematic review of four randomized and seven observational trials, the authors found AVF-related infections to be increased with the BH method compared with the RL method (RR, 3.3; 95% CI, 0.91 to 12.20) (23).

Patient satisfaction, pain with cannulation, and need for surgical or endovascular intervention was statistically not different between BH and RL.

### Perspectives from the Frontlines

The 2019 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-site-itis” (24). The guideline was justified based on international data analyzed from several randomized control trials and observational studies comparing the BH versus RL cannulation technique (22,23,25,26).

The issue of whether the renal community should support or discourage the use of BH cannulation is highly dependent on the vantage point of the party involved (27–29). Patients may rate their experiences with the BH technique favorably compared with the RL technique, with reduced pain, compression time, oozing, rebleeding, and increased ease of use (22). 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 the 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 rules are followed consistently.

Due to the subjective nature of individual life priorities, each informed discussion between clinician and patient should take into account that the relative weight of outcomes differs between patients, some of whom may be willing to accept a higher risk of infections in exchange for ease of self-cannulation or less perceived pain or discomfort. The perceptions of practicing nephrologists and advanced practice providers in the community are poorly described. Recently, the Nephrologists Transforming Dialysis Safety Initiative of the American Society of Nephrology (ASN) held a focus group session at the ASN Kidney Week 2019 asking if BH cannulation technique should be taught to patients on HHD and those on in-center HD (31). Table 1 lists selected comments. Some expressed a perception that the large dialysis organizations either did not allow or did not recommend the BH technique for in-center HD. Other respondents indicated that, because of lack of qualified dialysis staff, patients using BH who were 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 BH use.

Whereas the BH data reported by Canada, the United Kingdom, and other countries are likely generalizable to the United States, systemic and cultural healthcare factors unique to the HD population in the United States may further influence the risk of infection (32,33). Existing differences between the United States and Canada that may have an effect 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 HD facilities, local provider expertise in managing self-cannulation issues, and patient selection for HHD. There is a need for future, adequately powered, randomized controlled trials from HD centers in the United States to provide long-term, prospectively collected data and to adequately assess the risk and benefits of BH use in patients on both in-center HD and HHD in the United States.

### Future Research Needs and Potential

Because 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 dialysis organizations in the United States, Fresenius Kidney Care, DaVita, Dialysis Clinic Inc., Satellite Healthcare, and Northwest Kidney Centers, but none of these providers had data specific to BH-related bloodstream infections or access-related infections that could be studied versus RL technique. Fresenius reported infection prevention in patients on HHD is a major focus, with ongoing review of BH cannulation outcomes, dissemination of best practices, and adoption of a centralized access management system (D. Chatoth, personal communication). DaVita is similarly monitoring BH-

**Table 1. Nephrologists Transforming Dialysis Safety focus group responses from nephrologists and advanced practice providers**

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.”
Technique and training	“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.”
Best practices guidance	“Strict aseptic technique needs to be followed (do not use ‘scab removers’).” “NTDS should create a buttonhole registry.” “If NTDS would come up with a position or recommendations on using buttonholes, [we] would go with that.”

NTDS, Nephrologists Transforming Dialysis Safety.

associated infection rates, has implemented a topical mupirocin prophylaxis protocol, and has incorporated mandatory access care technique observation as part of HHD clinic visits (M. Schreiber, personal communication). Hopefully more granular details related to these approaches to BH cannulation will be available as more data are collected.

### Summary

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

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### Author Contributions

All authors wrote the original draft and were responsible for data curation; M. Mokrzycki and T. Vachharajani conceptualized the review; and K. Abreo, M. Mokrzycki, and T. Vachharajani reviewed and edited the manuscript.

### Disclosures

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