Preconditions that facilitate cannulation in arteriovenous fistula: A mixed-methods study

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Abstract

Background: Nurses have a great responsibility in the daily care of arteriovenous fistulae, which entails the potential to affect patency. However, good cannulation technique involves more than placing a needle in the vessel and relies on different skills to facilitate needling.

Objectives: To describe the preconditions for cannulation in arteriovenous fistulas.

Design: Descriptive statistics and qualitative content analysis were used in a mixed-methods design.

Participants: Haemodialysis units in Sweden.

Measurements: Local guidelines regarding arteriovenous fistula cannulation were analysed in parallel with responses to a questionnaire that contained open-ended and closed-ended questions on cannulation technique.

Results: Preconditions that facilitate cannulation fall into five stages, each with relevant factors in relation to the cannulation, as follows: planning cannulation—maturation and planning the cannulation, patient record, education and experience, and patient information; precannulation—physical examination, hygiene routines, arm position, tourniquet, choosing the cannulation site, and preventing pain; during cannulation—how to needle, type of needle, angle during cannulation, fixation, and adjusting; evaluating cannulation—blood flow rate and arterial and venous pressure; and postcannulation—needle withdrawal and haemostasis. The majority of dialysis units identified implementation of most of these preconditions, but the units handle several practical aspects differently.

Conclusions: Tracing the chain of cannulation led to identification of necessary preconditions for facilitating good cannulation technique. The findings also show the need for a better understanding of how different preconditions affect arteriovenous fistula and patency.

KEYWORDS
buttonhole, complications, haemodialysis, hygiene, nursing
INTRODUCTION

For those who need haemodialysis, an arteriovenous fistula (AVF) is the most common and favourable access to the blood stream (Lok et al., 2020; Schmidli et al., 2018). The treatment requires one arterial and one venous cannulation. This step is usually repeated three times a week all year round. Good cannulation technique is therefore crucial to appropriate AVF care. Cannulation may affect both AVF outcome and the patient’s experience, so the process of cannulation needs close attention.

LITERATURE REVIEW

Five cannulation techniques are described in the literature: rope ladder, area puncture, buttonhole using blunt needles (Gallieni et al., 2019; Schmidli et al., 2018), buttonhole using sharp needles (Morselli et al., 2015; Staaf et al., 2021) and Multiple Single cannulation Technique (MuST) (Peralta et al., 2021). Different regions use each technique to varying degrees; for example, area puncture is the most common technique in Europe (Parisotto et al., 2017), rope ladder is most common in Australia (Coventry et al., 2019) and the United States (Lyman et al., 2020), and buttonhole using blunt needles is the favoured technique in Sweden (Staaf et al., 2021).

The main aim when caring for an AVF is to maintain a ‘good cannulation technique’ (BRS/VASBI, 2018; Staaf et al., 2022), one that preserves AVF function, prevents AVF complications (Viecelli et al., 2020), and is quick and easy to use (Wilson & Harwood, 2017). Good cannulation technique is not the same as successful cannulation, as the term ‘successful cannulation’ references only a single needling attempt. It is therefore important to consider that the cannulation may be successful even if the cannulation technique is not good. The process includes more than the needling itself. Canaud described it as a drama in three acts—the preparation, the cannulation, and the disconnection—and it requires nurses to have both knowledge and skill (Parisotto & Pancirova, 2018). However, the cannulation process needs to be described in detail for a better understanding of what good cannulation technique looks like and to emphasise its importance.

To characterise good cannulation technique, earlier studies mainly compared rope ladder and buttonhole using blunt needles. The results are disparate, and the most favourable technique remains to be identified (Fielding et al., 2021). One reason for divergent results is that studies have used different techniques and do not fully describe all preconditions used to facilitate the cannulation. Examples of such preconditions include hygiene routines (Labriola et al., 2011; M. M. van Loon et al., 2010), tools (such as ultrasound and tourniquet) (Coventry et al., 2019; Kamata et al., 2016), prevent the occurrence of complications (Staaf et al., 2021), the direction of the needle during cannulation (anterograde or retrograde), or whether the needle is rotated during or after cannulation (Parisotto et al., 2017). One crucial facilitating factor in the cannulation process is hygiene. AVF infections decrease if nurses are trained in appropriate hygiene practices around cannulation (Labriola et al., 2011; M. M. van Loon et al., 2010).

Studies of appropriate care for the AVF during cannulation are scarce, and comparing available reports is difficult because of unclear and variable descriptions of the process. By identifying as many factors as possible that influence the cannulation process, each part can be studied so that all facilitating factors are highlighted for inclusion in future cannulation technique studies. Because nurses bear the responsibility for the choice of cannulation technique and the daily care of the AVF, they also have the potential to affect AVF patency (Staaf et al., 2022). The aim of this study was to describe different preconditions that facilitate good cannulation technique in AVFs.

MATERIALS AND METHODS

Design

This study relies on a convergent mixed-methods design with an inductive approach. Both data and method triangulation allow for a more complete understanding of the research question, and looking at the issue from different angles can yield more valid results. The reporting of findings in this paper is based on Good Reporting of A Mixed Methods Study (i.e., GRAMMS) (O’cathain et al., 2008).

Data collection

Data collection and analysis have been mainly described previously (Staaf et al., 2022). An overview of the methods is found in Supporting information: File 1.

Analysis

Local guidelines (LGs) and the answers to the open-ended questions were analysed using inductive qualitative content analysis (Elo & Kyngäs, 2008). Closed-ended questions were analysed using mainly descriptive statistics, and the analyses were performed in parallel. The results were then integrated into a final result (Creswell, 2014).

LGs and open-ended questions also were analysed in parallel. For this analysis, the text was read several times, and meaning units and codes were noted. Codes were then compared, grouped, and reduced to subcategories and categories. All of this was done with the study aim, main text, and meaning units kept in mind (Table 1).

Closed-ended questions were mainly described using descriptive statistics, and data were analysed using mean and standard deviation. Microsoft Excel 2016 (Microsoft) was used to collect and group data, and statistical analysis and randomisation of participants were performed using IBM SPSS Statistics, version 27 (IBM Corp.).
The findings from the qualitative content analysis gave the main structure to the result presentation. The quantitative data worked as a complement and were integrated into the results if the same theme emerged as a facilitating factor in the qualitative findings. In this way, the answers from the participating units gave structure to the results. The closed-ended answers from the survey developed and broadened the results without any influence that the authors may have built into the questionnaire.

**Ethical considerations**

The Swedish Ethical Review Authority gave ethical approval (No. 2020-04539) to the study. Written informed consent was obtained before participation.

**RESULTS**

Analysis of LGs from the 29 participating units and the 37 nurse respondents yielded 5 categories and 18 subcategories, presented below. Characteristics of the participating nurses and their dialysis units are presented in Table 2.

**The chain of AVF cannulation**

The categories that emerged during analysis of the LGs and the open-ended questions in the survey had a clear time relationship with the actual cannulation. The different categories are both dependent on and connected to each other like links in a chain (Figure 1). The preconditions for a good cannulation technique that were found during the qualitative analysis are described below as subcategories.

- **Planning cannulation**
  - Maturation and cannulation in new AVF
- **The chain of AVF cannulation**
  - The same site and angle during several dialysis

**Abbreviation:** AVF, arteriovenous fistula.
During a first cannulation, action is taken to reduce stress and risk of infiltration. For example, if the patient is scheduled to start after the other patients, dialysis is begun on the central venous access device (CVAD), needling is performed when other patients are started, and anticoagulation is reduced. Only two to three experienced nurses are allowed to cannulate the AVF during the first treatments.

Citation from LG unit 6: Take your time; if possible, start the new fistula last. Feel free to start using the CVAD and cannulate the new fistula when all other patients have begun their treatment.

If the patient has a CVAD, the recommendation is to use only one needle when the AVF is new. When applying this routine, some units noted that the catheter should be used as the vein to prevent haematoma in case of infiltration. Other units recommended using the CVAD as the artery and the AVF as the vein to contribute to increased maturation.

**Patient record**

The patient record is used as a tool to share results of examinations, cannulation difficulties, needling plan, maturation and descriptions of material used (such as type and size of needle, fixation material). LGs highlight the importance of both documenting and reading the existing text to facilitate cannulation and care of the AVF. Several of the LGs also recommend

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n = 37</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women/men, n (%)</td>
<td>33 (89%)/4 (11%)</td>
</tr>
<tr>
<td>Age (mean ± SD)</td>
<td>46.33 ± 9.95 (28–65)</td>
</tr>
<tr>
<td>Years of experience of dialysis (mean ± SD)</td>
<td>12.97 ± 7.73 (2–34)</td>
</tr>
<tr>
<td>Experience from 1/2–3/&gt;3 dialysis units</td>
<td>24 (65%)/8 (22%)/5 (14%)</td>
</tr>
<tr>
<td>Size of hospital, n = 37</td>
<td></td>
</tr>
<tr>
<td>University hospital</td>
<td>6 (16%)</td>
</tr>
<tr>
<td>Medium hospital</td>
<td>14 (38%)</td>
</tr>
<tr>
<td>Small hospital</td>
<td>12 (32%)</td>
</tr>
<tr>
<td>Other location than hospital</td>
<td>5 (14%)</td>
</tr>
<tr>
<td>Type of haemodialysis unit</td>
<td></td>
</tr>
<tr>
<td>In-hospital haemodialysis</td>
<td>81.9% ± 22.5 (0–100)</td>
</tr>
<tr>
<td>Self-haemodialysis</td>
<td>15.7% ± 18.6 (0–75)</td>
</tr>
<tr>
<td>Home haemodialysis</td>
<td>4.7% ± 9.0 (0–50)</td>
</tr>
<tr>
<td>Number of patients per dialysis unit</td>
<td>46.2 ± 25.4 (12–134)</td>
</tr>
<tr>
<td>Number of AVFs per dialysis unit</td>
<td>27.0 ± 16.4 (5–80) (58.4%)</td>
</tr>
<tr>
<td>Patient–nurse ratio</td>
<td>2.8 ± 7.4 (1–5)</td>
</tr>
<tr>
<td>Dialysis units that use BHb</td>
<td>37 (100%)</td>
</tr>
<tr>
<td>Dialysis units that use BHs</td>
<td>28 (76%)</td>
</tr>
<tr>
<td>Dialysis units that use RL</td>
<td>18 (49%)</td>
</tr>
<tr>
<td>Dialysis units that use AP</td>
<td>7 (19%)</td>
</tr>
</tbody>
</table>

Abbreviations: AP, area puncture; AVF, arteriovenous fistula; BHb, buttonhole using blunt needle; BHs, buttonhole using sharp needle; RL, rope ladder; SD, standard deviation.

The difference between small and medium hospitals is that small hospitals do not have an open emergency department during nights.

**FIGURE 1** The chain of arteriovenous fistula cannulation
taking pictures of the AVF to record maturation, describe complications and show the direction of the needle. How often the responding nurses documented different cannulation-related events is shown in Figure 2, and different methods of documentation are shown in Table 3.

**Table 3** Different ways to document cannulation and their frequency of use, the number of access coordinators, access nurses and units having access rounds, and number of units having access education during introduction of new dialysis nurses and regularly later on

<table>
<thead>
<tr>
<th>Documentation</th>
<th>n = 37; n, (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain text</td>
<td>29 (81)</td>
</tr>
<tr>
<td>Care plan</td>
<td>17 (47)</td>
</tr>
<tr>
<td>Cannulation schedule/needling plan</td>
<td>23 (64)</td>
</tr>
<tr>
<td>Photo</td>
<td>17 (47)</td>
</tr>
<tr>
<td>Dialysis protocol</td>
<td>6 (17)</td>
</tr>
<tr>
<td><strong>Coordination and planning</strong></td>
<td></td>
</tr>
<tr>
<td>Access coordinator</td>
<td>3 (8)</td>
</tr>
<tr>
<td>Access nurse</td>
<td>37 (100)</td>
</tr>
<tr>
<td><strong>Access education</strong></td>
<td></td>
</tr>
<tr>
<td>During introduction</td>
<td>37 (100)</td>
</tr>
<tr>
<td>Regularly</td>
<td>19 (51)</td>
</tr>
</tbody>
</table>

**Citation from LG unit 28:** Write in the patient record, as accurately as possible, the angle of the needle. Also take a picture for the patient’s folder, where the needle direction and the position of the arm are shown.

**Education and experience**

Both LGs and responding nurses described cannulation and the knowledge about caring for the AVF as built on experience. For example, several units recommend that only experienced nurses should be allowed to cannulate new AVFs and create tunnel tracks. LGs also refer to a more experienced colleague or the access nurse if there are questions about cannulation and AVF care.

**Citation from LG unit 15:** An experienced dialysis nurse shall cannulate the AV-fistula, using a good cannulation technique, during the first six treatments.

According to the survey, a nurse who cannulates a new AVF should have dialysis experience of at least an average of 9.03 months (±7.52, median 6 months, range 2–36 months). When creating a new tunnel track (buttonhole using blunt needles), the nurse’s experience should be at least an average of 8.72 months (±6.5, median 6 months, range 2–36 months).

Cannulation education is performed during introduction of new dialysis nurses and during further training (Table 3). In the
open-ended questions, nurses described cannulation technique, measurement of AVF flow, POCUS, different types of AVF, and new research as subjects that are common in these kinds of education experiences.

LGs refer to the access nurse/access group regarding coordination of cannulation in new AVFs, complications, and planning of AVF care (Table 3). Planning for new AVFs and how to treat AVF complications is also done during so-called access rounds. During these appointments, there is a meeting of the access team, for example, the access nurse, nephrologist and vascular surgeon. Most often, dialysis units/hospitals have their own meetings, but in some cases, smaller dialysis units cooperate with a neighbour hospital and join the round virtually. According to the survey, access rounding was performed an average of 26 ± 16.78 times/year (range 0–52) at 32 (86%) of the answering units.

Patient information

Before the first cannulation, LGs state that patients should be informed, but recommendations about the content of that information vary among participating nurses and units. Common subjects include what they may or may not feel during the first cannulation, the possibility of using analgesics, arm wash before treatment, the importance of calling for help if they feel pain during treatment, and how to handle acute bleeding at home.

Citation from LG unit 29: Inform the patient before the first cannulation. Describe the procedure and tell the patient to call if they feel pain or discomfort.

The information is given both orally and in writing. In one region, patients also receive a bracelet that reads, ‘Do not touch my veins here’, to wear on the AVF arm.

Precannulation

Physical examination

Different types of examinations are described in the LGs. Most units recommend measurement of AVF flow but differ in how often they say this routine should be performed, from monthly to every third month (or every 6 months if the patient has home haemodialysis). All but two units (95%) use an ultrasound dilution technique to measure AVF flow, and the remaining two use the haemodialysis monitor and duplex ultrasound. AVF flow is measured an average of 7.8 ± 1.2 times/year (range 4.5–11). A physical examination is recommended as preparation for cannulation. Some units recommend only inspection of the AVF, whereas others recommend that the nurse inspect, auscultate, and palpate the AVF to discover signs of complications and plan for new cannulation sites (if using rope ladder). Still other units recommend inspection and/or palpation and that the nurse perform auscultation only if the search yields anything unusual (Figure 3).

Citation from LG unit 4: If you find anything abnormal during palpation, listen to the AVF to examine if the thrill changes along the vessel.

The use of POCUS is also recommended in the LGs, especially if the AVF is new and during cannulation difficulties. All but four nurses

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**Figure 3** Estimations from nurse respondents of how often they perform different physical arteriovenous fistula examinations during a normal week. Inspection, 0.96 ± 0.17; palpation, 0.92 ± 0.22; auscultation, 0.22 ± 0.25 (n = 37).
reported sometimes using POCUS during cannulation (Figure 4). Nurse respondents were asked to rate POCUS between 1 (worst) and 4 (best), and the mean rating was 3.5 ± 0.72 (range 1–4).

Hygiene routines

The LGs describe hygiene routines for both nurse and patient. In several of the units, patients are told to wash their arms before treatment (Figure 5). Nurses are recommended to use basic hygiene procedure and wear apron, gloves, mask and/or visor during cannulation.

Cannulation is described as an aseptic process, but the participating units described different methods of cannulation site disinfection. Some LGs recommend disinfecting the whole AVF area from top to bottom, whereas others recommend more local disinfection, such as to a radius of 5 cm around the cannulation site. Some LGs recommend that the disinfection should be performed in a circular sweep, but others recommend disinfection in one straight direction, using a new gauze for each draw (Figure 6). When buttonhole is used, LGs recommend that scabs should be removed and the area disinfected before and after scab removal. Some LGs also highlight the importance of using one scab picker for each hole.

Citation from LG unit 11: Scabs shall be removed if buttonhole is used. Use two scab removers/cannulas after disinfection. The sites shall then be re-disinfected, using a well-moistened gauze and allowed to air dry.

All units but one normally use chlorhexidine 5 mg/ml during disinfection before cannulation, and the remaining unit uses 70% ethanol. Only four units disinfect the cannulation site after needle withdrawal. None of the participating units use antiseptic treatment with buttonhole. All nurses responded that they remove scabs and disinfected before and after scab removal every time when using buttonhole with sharp needles and buttonhole with blunt needles. Tools for scab picking differed between units. Blunt cannulas and the lid on the dialysis needle were most common. Some units also used a sharp cannula, a plastic tool for scab picking and soiled gauze.
Position of the arm

The LGs state that the patient should be in a comfortable position during cannulation. Units also describe the importance of using the exact same position of the arm during needle insertion to ease buttonhole cannulation. Several LGs state that the arm should be visible during the treatment. If a patient thinks it is difficult to keep the arm still, the limb may be tied to the chair or bed.

Tourniquet

Recommendations for use of a tourniquet during cannulation differ among LGs. In some units, a tourniquet is mandatory during cannulation, but other units leave it up to the nurse to decide. Reported alternatives are blood pressure cuff with a maximum pressure of 40–60 mmHg, a medical tourniquet, or a colleague compressing the vessel.
The nurse respondents estimated that they used tourniquets during a normal week on 37 ± 35% (range 0%–100%) of patients (Figure 7).

Choosing a cannulation site

LGs recommend that the arterial needle not be placed too close to the anastomosis, giving a distance range of 2 to 5 cm. Guidelines also state that the arterial needle can be placed both retrograde and anterograde. The venous needle should be placed 3 to 8 cm from the arterial needle because a short distance might increase the risk of recirculation. If rope ladder is used, two of the LGs recommend moving the next cannulation site 0.5 to 2 cm from the last site.

Preventing pain

LGs describe different ways to prevent pain during cannulation. Nurses are recommended to inform patients about analgesics, but patients are left to apply it themselves (Figure 8).

The nurse respondents estimated that they used tourniquets during a normal week on 37 ± 35% (range 0%–100%) of patients (Figure 7).

Citation from LG unit 22: The needles shall be placed at least 3 cm from the anastomosis. The distance between the needles should be at least 3 cm.

Citation from LG unit 9: Mark the cannulation sites and tell the patient to apply the analgesic plaster one hour before the next dialysis. If needed, hand the patient the plasters.

FIGURE 7 Use of different types of tourniquet as reported by nurse respondents. One nurse could use several types of tourniquets (n = 37).

FIGURE 8 Estimates from nurse respondents of the proportion of patients using different types of analgesics before cannulation. Plaster lidocaine/prilocaine, 0.62 ± 0.27; intracutaneous injection, 0.02 ± 0.06; lidocaine spray, 0.08 ± 0.12; no analgesic, 0.28 ± 0.24 (n = 37).
During cannulation

How to needle

Several units recommend priming the needle tube using sodium chloride before cannulation (Figure 9), but units vary in guidance for how to hold the needle and the vessel during cannulation. Some units state that the skin should be tightly held during needling, whereas others say the reverse. Some units recommend the tunnel track to be steep and then flatten, but according to others, a steep tunnel could create cannulation difficulties.

When using buttonhole with blunt needles, the needle should not be forced into the vessel because doing so increases the risk of false tracks. The tube (not the wings) can be held and gently wiggled and the needle rotated into the track. If the track is not found immediately, the angle of the needle may need to be adjusted. If re-cannulation is needed, some units allow for insertion of a sharp needle in the same track using touch cannulation. Other units, however, call for use of a new temporary site if a blunt needle cannot be inserted.

Citation from LG unit 29: If the tunnel track is not found, try to adjust the angle and direction of the needle. It is also possible to tighten the skin in different ways.

Some units recommend rotation of the needle after the insertion, to optimize the flow. Other units advise against needle rotation out of concern that it might increase the width of the track and damage the intima (Figure 9).

Type of needle

Units vary in guidance related to needle size and design, at least when the AVF is considered to be new. A few units recommend a plastic cannula as preferable when the AVF is new or if the patient is moving around, because the plastic decreases the risk of infiltration during dialysis treatment.

During the first cannulation in the AVF, some units recommend a 17 G needle, others 16 G and 2 units use 15 G. LGs also state that the choice of needle size should be based on vessel width, blood flow, venous pressure, or number of dialyses after the first cannulation. Most units recommend 15 G for standard use when the new period of an AVF ends.

Citation from LG unit 16: Change to a larger needle size, i.e., 15 G, when five treatments, free from complications, have passed and a blood flow of 270 ml/min has been reached.

According to the survey, the distribution of needle size in participating units was 9% using 17 G, 16% using 16 G, 62% using 15 G and 13% using 14 G.

Angle during cannulation

If buttonhole is chosen, the recommendation is to use the same angle during every cannulation. Some units hold that if different angles are used, false tracks may arise that in turn may increase risk for bacterial growth. Units differ in recommended angles, calling for 20°, 20°–30°, 25° or 45°. Other units state that the angle should be adjusted.

![Figure 9](https://example.com/image9.png) Estimates from nurse respondents of the proportion of patients whom they cannulate using bevel up, directing the needle retrograde, using needles primed with sodium chloride, and rotating the inserted needle after cannulation. Bevel up, 0.74 ± 0.39; retrograde cannulation, 0.07 ± 0.19; priming needle tube, 0.62 ± 0.46; needle rotation 0.39 ± 0.35 (n = 37).
depending on the depth of the AVF. The bevel direction during cannulation is also variable among units. One unit says the bevel should be up when the needle is anterograde and down if retrograde, and another unit recommends that patients who cannulate themselves should use the bevel down, but that when nurses needle the AVF, the bevel should be up. Units recommending bevel down state that this technique decreases risk of infiltration and long bleeding time postdialysis and increases healing. Cannulation using bevel up is the most common technique (Figure 9).

Fixating and adjusting

When one needle has been successfully inserted and flow control is performed, needle fixation is needed to prevent cannulas from moving or withdrawal during treatment. Units vary in their descriptions of how the fixation should be performed. Most often, the recommendation is that the tape covers the wings and prevents the needle from going backwards. Some units say that the tape should cover the cannulation site, whereas other units state that the needle hub should be visible.

Citation from LG unit 27: Fix the needle and control its position through aspiration a few more times for optimal needle flow.

The fixation should be changed if the skin becomes moist. Extra fixation may be needed if the patient has generous arm hair or moves around during treatment. Some units describe the importance of not inserting the whole needle into the vessel and of keeping 2–3 mm outside to prevent hubbing (and increased risk for infections).

Fixing the tubing to a patient’s shirt, bed sheet, or hand is also recommended to prevent the weight of the tube from pulling the needle. Some units also highlight the importance of checking the fixation at least once an hour during dialysis.

Evaluating cannulation

Blood pump speed

LGs describe that the blood pump speed in a mature AVF is often set to 250–350 (400) ml/min when using a 15 G needle. However, LG recommendations differ when describing the pump speed in a new AVF. Some units recommend a new AVF blood pump speed of 150 ml/min, to be increased after 2–3 weeks. Other units set the first blood pump speed at 200–225 ml/min, followed by an increase to 20–50 ml/min per treatment.

Citation from LG unit 22: Always use a lower blood pump speed when the AV-fistula is new. The new fistula has an increased risk of infiltration because the vessel walls have not matured and arterialised.

Arterial and venous pressure

To evaluate placement of the needle, LGs recommend monitoring of arterial and venous pressure during dialysis. The lower limit of arterial pressure during first cannulations is set to –100 mmHg, but as time passes, the limit is allowed to drop to –200 mmHg as blood flow is increased. Vein pressure is evaluated in a similar way. It is recommended that vein pressure not be raised above 100 mmHg during the first treatments, and when the AVF is matured, the vein pressure should not rise above 150 to 200 mmHg.

Postcannulation

Needle withdrawal

When the dialysis treatment is ended, needles are withdrawn. Two units recommend that one needle is withdrawn at a time and that haemostasis is reached before the next needle is removed. However, most units say that needles can be removed simultaneously. LGs also recommend that the needle be withdrawn at the same angle as for its insertion and that no pressure be applied before the needle is completely removed. Most LGs recommend compression using sterile or clean gauze.

Haemostasis

Some LGs recommend pressure be applied using one finger, and others recommend using two fingers per site. The pressure should be constant and not too strong, and the thrill in the AVF must be felt the whole time. Recommended compression times vary among units, with some recommending 5 min and others 10–15 min. Two of the units also highlight that during the first three cannulations, pressure should be held for 15–20 min (Figure 10). Some units describe different types of dressing used to reach haemostasis and emphasise informing the patient about when to remove the dressing.

A mechanical compression device is mentioned in some LGs. Two units discourage use of the device, but others indicate that it can be allowed if the AVF is well established or in life-threatening situations.

Needle withdrawal is recommended to be done simultaneously by 86% of units and one needle at a time by 14%. According to responses from nurse participants, patients perform compression after needle withdrawal 49% of the time and a healthcare provider does it 51% of the time.

DISCUSSION

This study describes different practical aspects of the needling process that facilitate good cannulation technique in AVFs. The process can be described as five links in a chain, namely planning, precannulation, during cannulation, evaluating cannulation, and postcannulation (Figure 1). These links are dependent on and
intertwined with each other because each one must be fulfilled to achieve the objective of a good cannulation technique.

The qualitative content analysis of the LGs made clear that buttonhole is the main cannulation technique in Sweden. The use of buttonhole permeates the text in the LGs and sometimes seems synonymous with cannulation, as it is the only technique described. This conflation may have affected the findings, but a main part of the five links in the chain of cannulation (Figure 1) appear transferable to other techniques. For example, physical examination, type of needle, and fixation of the needle ought to be the same regardless of cannulation technique. Further research is needed on this matter.

There are similarities among the LGs, and the majority of these documents describe each of the different parts of the cannulation process, although to varying degrees. The units also seem to agree about how to perform some of the preconditions. However, there is also a diversity in recommendations regarding performance of other parts of this process.

Units agree on the importance of experience and base the work regarding vascular access on so-called access nurses or access groups. Previous research has highlighted the importance of vascular access coordinators and the quality improvement they mediate to AVF care (Dinwiddie, 2007; M. van Loon et al., 2007). Another statement on which dialysis units agreed regarding good cannulation technique is continuity between nurses. This means that knowledge of the individual AVF through physical examination and descriptions of AVF and cannulations in the medical record is fundamental for the given care. Continuity may be of extra importance when buttonhole is predominant. Marticorena et al. (2006) found that each single nurse who cannulates a patient using buttonhole needs to know the individual AVF to insert the needle in exactly the same direction and angle.

Units also agree on the importance of hygiene, disinfection and scab removal, as is apparent both in the LGs and in the survey. Almost all units use chlorhexidine 5 mg/ml, and all participating nurses disinfect both before and after scab removal. Previous studies have shown that chlorhexidine is more effective than povidone-iodine (Yasuda et al., 2017), and differences in type of disinfectant used may influence infection outcomes (Christensen et al., 2018; Lyman et al., 2020). Earlier studies also have shown that recurrent training in hygiene routines when using buttonhole can lead to decreased infection rates (Labriola et al., 2011; M. M. van Loon et al., 2010).

Although the units agree on disinfection routines, they diverge when it comes to arm wash ahead of cannulation. Only 62% of the participating nurses stated that their unit recommends arm wash to their patients (Figure 5). The effect of arm wash in preventing AVF infections is unknown. The origin of the recommendation to wash the arm before haemodialysis is uncertain but likely traces to a study reporting that the degree of hygiene in patients on haemodialysis affects infection outcome (Kaplowitz et al., 1988). Further studies on this matter are needed.

The units disagreed in several areas, such as use of tourniquet, needle angle during cannulation, what to include in the physical examination ahead of cannulation, and needle size during cannulation. The parts of the cannulation process that units handle the same way are based on greater evidence and previous research, in contrast to preconditions such as tourniquet use and needle angle, for which research is lacking and recommendations are based on expert opinions. This lack of evidence has probably led nurses to find their own support for their performance of different tasks, and their proven experience gets traction in the unit.

The process of needling has been described as the craftsmanship of nurses (Parisotto & Pancirova, 2018) and an essential part of cannulation (Gallieni et al., 2019). The different parts of the process

![Figure 10](https://onlinelibrary.wiley.com/doi/10.1111/jorc.12448)

FIGURE 10 Estimates from nurse respondents of the proportion of patients for whom they use different methods to achieve haemostasis after needle withdrawal
also have been described, but only as a single stage, not as a series of links. Previous studies on cannulation technique have shown variation in outcomes (Fielding et al., 2021), and because descriptions of the different parts of the cannulation process often are not included, comparing outcomes can be difficult. One reason for these differences may be that parts of the cannulation process have differed and that these variations may confer bias.

This study has strengths and weaknesses. One strength is the combination of qualitative and quantitative data, which gives a broader perspective. Another strength is that participating units were evenly distributed over the whole country and different sizes of hospitals. One limitation is that just over 50% of the invited units participated. Another limitation is that the written answers from the nurses may have been influenced or inspired by the questions in the survey.

IMPLICATIONS FOR CLINICAL PRACTICE

This study highlights the importance of different preconditions that facilitate cannulation in AVF and describes the parts in this process. This work has been characterized previously as the craftsmanship of nurses, but if a process and its parts is not delineated in words, their importance can be overlooked. Therefore, this study may aid dialysis providers and researchers in acknowledging each precondition and its performance, which may affect the potential patenty of AVF.

CONCLUSIONS

This study shows that cannulation is more than insertion of a needle in the vessel. To achieve good cannulation technique, all parts of the cannulation process must be completed well. Planning cannulation, precannulation, during cannulation, evaluating cannulation and post-cannulation all work together like links in a chain and are dependent on each other. If cannulation is performed without each link in the chain or by including the links in a variable way, different cannulation techniques will be hard to compare and evaluate. It is therefore important to include descriptions of all five links of the cannulation process in studies comparing cannulation techniques. It is also important to include these steps when educating dialysis providers in cannulation technique.

AUTHOR CONTRIBUTIONS

Research idea and study design: Karin Staaf, Anders Fernström, Fredrik Uhlin. Data acquisition: Karin Staaf. Data analysis/interpretation: Karin Staaf, Fredrik Uhlin. Supervision/mentorship: Fredrik Uhlin, Anders Fernström. Each author contributed important intellectual content during manuscript drafting or revision.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing not applicable due to privacy/ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.