An Improved Approach to Graph Cannulation

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For patients, cannulation is a time of stress, involving pain and possible complications (e.g., cannulation failures, loss of thrill). A worst case is when a graft must be replaced with a new access. One cause for graft replacement is weakening of the graft material (e.g., polytetrafluoroethylene) due to repeated cannulation over time. The approach described here uses a cannulation care plan, which is an outline of the patient's graft and arm, including the following:

1. Alert areas (graft areas unsuitable for cannulation);
2. Interval IDs (graft areas suitable for cannulation); and
3. Rotation order (cannulation sequence for successive treatments).

Example: If the interval IDs are sequentially labeled A1 to A7, M (midpoint), and V1 to V7, then the rotation order can be as follows:

A1/V1 → A5/V5 → A2/V2 → A4/V4 → A7/V7 → A3/V3 → A6/V6. Repeat.

The approach given here was studied on one patient (her third graft) with the following result. The graft endured for 6+ years of use (electively retired), which was three times longer than her two prior grafts, which were cannulated without this approach. *Figure 1A* and *B* are examples of the cannulation care plan for this patient, defined several years apart and edited for publication clarity (no substantive change). {FIG1}

Overview of the Approach (to be applied for each patient)

Stage 1: Define the Cannulation Care Plan

Stage 1 is repeated when there is a change in *alert areas*. Use *transparency film* (TF) to draw an actual-size outline of the patient's graft, including alert areas and the perimeter of the arm. On the *outline*, label *interval IDs* and state the recommended *rotation order*.

Stage 2: Implement the Cannulation Care Plan in Accordance with Good Practice

Stage 2 is performed for each dialysis treatment.[1] Select, mark, prep, and cannulate suitable sites in the A/V interval IDs targeted for today. Next, for each site cannulated, draw a dot on the outline. Separately, record the interval IDs cannulated, in order to determine the next interval ID in rotation order (next time).

Details of the Approach (to be applied for each patient)

Stage 1: Define the Cannulation Care Plan

Repeat Stage 1 to the extent needed, e.g., when a new alert area is detected, or a former alert area heals. (This consists of updating or replacing the outline and rotation order.)

1. Prepare to draw the outline:
   * Using *raw materials*, e.g., TF with a 1 × 1-cm grid, print the patient's last and first name, ID number, and today's date on the bottom.
   * Ask the patient to position his or her arm in the manner used for cannulation.
   * Place the TF on the patient's arm so the entire graft and anastomoses are in view. If one TF is too small, tape multiple TFs side by side (use double-sided tape).
2. Create an actual-size outline of the patient's graft, including alert areas, as follows (see *Figure 2* for an example of an outline):
   * Draw (trace) an image of the patient's graft and arm on the TF, including the:
     - Entire graft and both anastomoses;
     - Alert areas, i.e., areas unsuitable for cannulation, including pseudoaneurysms scar lines or scar tissue, thrombectomy incision-entry sites, infections;
     - Arm perimeter in view, e.g., the outer/inner arm, shoulder, armpit, wrist; and
     - Other image-able information in view (i.e., visual details to "line up" and use the outline like a "treasure map" to guide and track cannulation sites).
   * Label the image (exclude interval IDs) per the template/key (*Figure 3*).
3. Draft a set of intervals that are "equally suitable" for cannulation. The intent is to divide the "graft areas suitable for cannulation" into intervals, typically 1 cm wide. However, adjust interval widths as makes sense for cannulation rotation: use wider intervals where cannulation choice is limited, e.g., at curves or near alert areas.
   * Place the outline TF on a clean, flat surface (with white paper as background).
   * Overlay blank TF (without grid lines) onto the outline TF, for use as a *draft*.
   * Draw (trace) the graft and alert areas onto the draft, so both TFs line up easily.
   * On the draft, define a set of intervals (sized "equally suitable for cannulation"):
     - Exclude areas that are "too close" to anastomoses (called *buffers* here);
     - Exclude areas that are "too close" to alert areas (if necessary).
   * Count the resulting number of intervals suitable for cannulation as the *total*. If this total is odd, adjust the interval widths on the draft, so that an even total results.
   * Divide this total by 2 to determine N (number of mated pairs of interval IDs).
4. Draw and label the outline with interval IDs, by transposing the draft to the outline:
   * Reverse and line up the TFs, so that the outline TF is now on top of the draft.

DOI: 10.1002/dat.20610

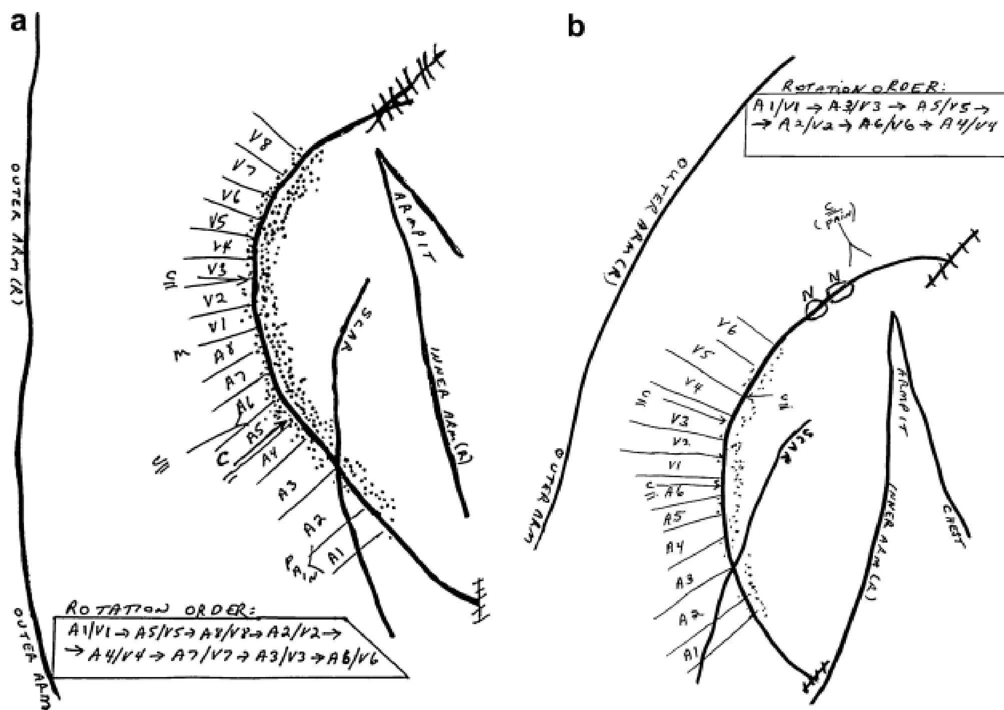


FIGURE 1. *(A, B) Cannulation Care Plans for the study patient (at two points in time).*

- ⁎ Draw (trace) the set of intervals from the draft to the outline TF.
- ⁎ Sequentially label the interval IDs, i.e., label the:
  - Intervals from the arterial anastomosis (post buffer), as A1 to AN;
  - Endpoint of interval AN as M (graft midpoint); and
  - Intervals from M to the venous anastomosis (pre-buffer), as V1 to VN.

5. Define a *rotation order* for the N *mated pairs* in a manner that avoids cannulation of adjacent sites in successive treatments. Examples: When N = 7, the rotation order can be:

A1/V1 → A5/V5 → A2/V2 → A4/V4 → A7/V7 → A3/V3 → A6/V6; Repeat.

When N = 8, the rotation order can be:

A1/V1 → A4/V4 → A7/V7 → A2/V2 → A5/V5 → A8/V8 → A3/V3→ A6/V6; Repeat.

Stage 2: Implement the Cannulation Care Plan

Stage 2 is performed at each treatment, in a manner that is consistent with good practice. Inform a *cannulation care contact* if a new alert area (e.g., pseudoaneurysm, infection) or *site/area of concern* (e.g., extreme pain, ooze, flat/mushy) is detected, so that the cannulation care plan may be updated, as needed.

1. Identify the interval IDs targeted for today, i.e., the next mated pair in rotation order based on the interval IDs cannulated during the previous treatment.
2. Use the outline TF to locate the interval IDs targeted for today on the patient's graft.
3. In each interval ID, choose and mark desirable cannulation sites with a *skin marker*: mark each site by drawing a line perpendicular to the graft (not touching the graft).
4. Prep/cleanse and cannulate the patient's graft.
   - Experienced staff may elect to cannulate "ever-so-slightly left or right" of the graft's center to increase the lateral area of use (supports longevity of the graft).
   - If a cannulation fails, then use the next suitable site in the rotation order, e.g., if A5/V5 is targeted, but V5 infiltrates, then select the next suitable venous site.
5. On the outline, mark each site cannulated today (including misses if any) with a *dot*. If "ever-so-slightly left or right" applies, record dots accordingly (use UF Sharpie).
6. Separately (not on the outline), record the date and interval IDs cannulated today (including misses, if any) in a common repository, e.g., online, or, in a folder with the cannulation care plan, where the data will be readily available for the next treatment.

Suggested Raw Materials for Use by Cannulation Care Contacts

Suggested raw materials are as follows:

- Multipurpose TF (for cannulation care plans);
- Write-on TF (for draft use during Stage 1);
- Downloaded graph paper with 1 × 1 centimeter grid; print this grid (with a printer) onto the TF;
- Double-sided tape, ½", permanent, clear (to tape TFs, side by side);
- Cotton tips, lightly moistened with alcohol prep pad (to erase Sharpie ink from TF);

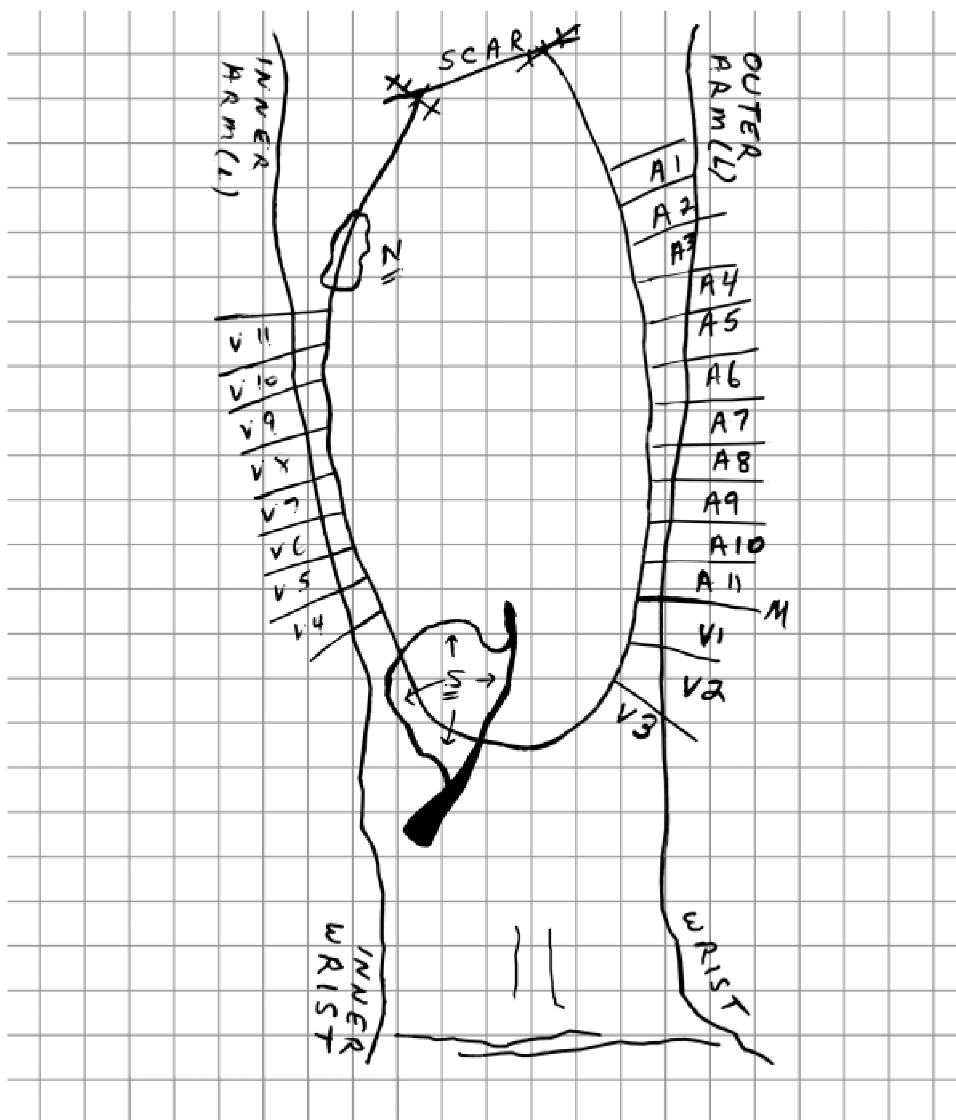


FIGURE 2. *Example of an outline, based on the template/key.*

- Permanent marker pens (permanent, black), both Ultra Fine and Fine, for defining and updating the cannulation care plan.

Suggested Raw Materials for Staff That implement the Cannulation Care Plan

Suggested raw materials for staff are as follows:

- Medline skin marker, #DYNJSM05 (to mark desirable cannulation sites);
- Retractable permanent marker pens (black), ultra fine tip (for dots).

Effort Estimate

For consistency, this author suggests that cannulation care contacts be assigned to define the cannulation care plans (Stage 1). It takes about 30 minutes per patient to complete Stage 1. The output is the cannulation care plan (as documented on the TF). Staff who can cannulate and "use a map" can implement the cannulation care plan (i.e., complete Stage 2), which takes about 5 minutes per patient per treatment. From time to time, an update to the cannulation care plan may also be needed during Stage 2. Nevertheless, the time differential to implement the cannulation care plan does not affect patient scheduling, since the lower frequency of minor complications (infiltration, oozing, pseudoaneurysm, pain) is likely to reduce time needed for the procedure, i.e., saving time via preventive action.

Benefits

When a graft fails and must be replaced due to weakening of the graft material over time, correction typically requires:

- Alternative dialysis (e.g., acute care, which may initially call for femoral access);

Graft (use Fine Sharpie):
Draw (trace) the exact image (actual size & shape) of the graft

Anastomoses (use Ultra Fine Sharpie):

Draw (trace) to the size of stitched or scarred area

Alert Areas (use UF Sharpie):

S Scar lines or tissue are drawn to actual size & shape, labeled "S".

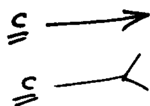
N Pseudoaneurysms are drawn to actual size & shape, labeled "N"

T Thrombectomy incision-entry sites are labeled "**T**" with a pointed arrow, drawn from the label "**T**" to the incision-entry site

F Infections (perimeter-to-avoid) are drawn to actual size & shape

Arm Perimeter-in-view:
Draw (trace) the arm perimeter-in-view onto the TF to actual size & shape – Fine Sharpie
Add minimal labels, e.g., Outer/Inner Arm, Shoulder, Armpit, Elbow, Wrist – UF Sharpie

Sites/Areas of Concern (sites/areas to be cannulated or not, i.e., subject to discretion):



Indicate Sites of Concern by an underlined "**c**" and pointed arrow. For Areas of Concern, use an open-ended arrow (sized to area) – UF Sharpie
Optionally, annotate the reason for the concern (1 or 2 words) – UF Sharpie

Other image-able information in-view: Drawn to the actual size & shape, these images are included as needed, so practitioners can easily use the Outline like a map to find Interval IDs for the Rotation Order. Examples: skin distortions, birth marks – UF Sharpie

Location Identifiers (use UF Sharpie):
M – Midpoint of the graft areas suitable for cannulation (not an interval)
A1, A2, A3, etc. – Arterial graft areas suitable for cannulation (intervals)
V1, V2, V3, etc. – Venous graft areas suitable for cannulation (intervals)

Rotation Order (use UF Sharpie):
Draw a rectangle on the TF. Print the Rotation Order inside, e.g. (when N=10):

Rotation Order:
A1/V1 → A3/V3 → A5/V5 → A7/V7 → A9/V9 → A2/V2 → A4/V4 → A6/V6→ A10/V10 → A8/V8; Repeat

Bottom ½" of Outline: Patient Last Name, First Name, ID#, Outline date – UF Sharpie

FIGURE 3. *Template/Key to draw and label the outline transparency film.*

- Procedures (e.g., permacath for temporary access);
- Diagnostics (e.g., extremity scans to plan the new access, pre-operative laboratory tests);
- Surgery (e.g., placement of new graft or fistula, recovery and follow-up care).

These additional medical costs are approximately $2,000 per incident.[2] More than 70,000 patients use grafts as their primary access.[3] If 2,500 access replacements are delayed per year by cannulation care plans (assumes 50 instances per state/year), then medical savings of $5,000,000/year ($2,000 × 2,500) are predicted with this approach.

Additional savings will apply if the frequency of thrombosis, stenoses, or infection is reduced by cannulation care plans. This topic merits study, as this patient's first and second (not the third) grafts incurred thrombectomies and infection. Angioplasty did not apply for this patient. Most important, extending longevity of grafts improves quality of life for patients.

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