Disclosure of Conflicts of Interest

“Venous Access in Adult Apheresis”

Jan Hofmann, MD has reported the following financial relationships with commercial interests related to the content of this educational activity:

Consulting Fees: Fresenius Medical Care
Venous Access in Adult Apheresis

Outline

• Temporary and tunneled double-lumen central venous catheters (CVCs)
  - Advantages and disadvantages
  - Trialysis CVCs, Power Hickman CVCs
• Placement of CVCs (where?, who?)
• Inpatient care of CVCs (port patency, dressing changes)
• Outpatient care of CVCs (keeping dressing dry & clean)
• Troubleshooting CVC malfunction (obstruction/fibrin sheaths; kinking; exit site inflammation/infection).
• Adverse Events (PTX; line infection; line migration)
• Removal of CVCs (exit site care)
• Optimization of peripheral access (hydration, patient preparation)
• Questions & Answers
The Choice of Vascular Access for Therapeutic Apheresis

Kambiz Kalantari*

Division of Nephrology, University of Virginia Health System, Charlottesville, Virginia

TABLE I. Main Determinants of Vascular Access for TA
(See Text for Further Details)

- Indication for TA
- Type of TA system used
- Number and frequency of treatments needed
- Anticipated duration of treatment

TABLE II. Option of Vascular Access for TA

<table>
<thead>
<tr>
<th>Access Type</th>
<th>Use</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral Vein</td>
<td>Short-term, less frequent and shorter treatments, large veins</td>
<td>Lower side effects, less invasive</td>
<td>Thrombophlebitis, not suitable for cases with high platelet or WBC counts, not suitable for filter-based systems</td>
</tr>
<tr>
<td>Nontunneled CVC</td>
<td>Short-term treatments, filter-based and centrifugation-based systems</td>
<td>Better BFR compared to peripheral veins</td>
<td>Risk of infection, not suitable for prolonged TA, patients cannot bathe or swim</td>
</tr>
<tr>
<td>Tunneled CVC</td>
<td>Long-term (weeks to months) treatments, filter-based and centrifugation-based systems</td>
<td>Lower infection rates compared to nontunneled CVC</td>
<td>Higher infection, malfunction and mortality rates compared to AVF, patients cannot bathe or swim</td>
</tr>
<tr>
<td>Totally implantable ports</td>
<td>Long-term (weeks to months) treatments, filter-based and centrifugation-based systems</td>
<td>Lower infection rates compared to tunneled CVC, patients can bathe, swim and exercise</td>
<td>Infection and thrombosis</td>
</tr>
<tr>
<td>AVF</td>
<td>Long-term (years) treatments</td>
<td>Lowest complication, cost and mortality rates</td>
<td>Issues with maturity and maintenance</td>
</tr>
</tbody>
</table>

# Vascular Access in Therapeutic Apheresis: Update 2013

Ladan Golestaneh and Michele H. Mokrzycki*

*Division of Nephrology, Department of Medicine, Albert Einstein College of Medicine, Bronx, New York

## Table III. A Comparison of the Advantages and Disadvantages Associated With Vascular Access Types Used in Therapeutic Apheresis (TA) Procedures

<table>
<thead>
<tr>
<th>Vascular access type</th>
<th>Indications for use</th>
<th>Advantage</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral Veins</td>
<td>Centrifugal based TA</td>
<td>Low rate of infections</td>
<td>Patient discomfort</td>
</tr>
<tr>
<td></td>
<td>Acute or intermittent TA</td>
<td>Immediate use</td>
<td>Infiltration and sclerosis of veins</td>
</tr>
<tr>
<td></td>
<td>Short term use only (&lt;2 weeks)</td>
<td>Easy to place at bedside</td>
<td>Risks inherent to catheter insertion</td>
</tr>
<tr>
<td>Non-tunneled central venous catheters</td>
<td>Acute or intermittent TA</td>
<td>Blood flow rate high</td>
<td>Dysfunction</td>
</tr>
<tr>
<td></td>
<td>Centrifugal or filter based TA</td>
<td></td>
<td>Infection, including sepsis, and metastatic infections</td>
</tr>
<tr>
<td>Tunnelled central venous catheters</td>
<td>Short or long term use</td>
<td>Reduced infection rate when compared to non-tunneled catheters</td>
<td>Central vein stenosis</td>
</tr>
<tr>
<td></td>
<td>Centrifugal or filter based TA</td>
<td>Blood flow rate high</td>
<td>Dysfunction</td>
</tr>
<tr>
<td>Arteriovenous Fistula (AVF)</td>
<td>Chronic TA (&gt;3 months)</td>
<td>Lowest infection and dysfunction rates compared to other vascular access types</td>
<td>Requires surgery and adequate patient vascular anatomy</td>
</tr>
<tr>
<td></td>
<td>Centrifugal or filter based TA</td>
<td></td>
<td>Requires a maturation period before use (~6-8 weeks)</td>
</tr>
<tr>
<td>Arteriovenous grafts (AVG)</td>
<td>Chronic TA (&gt;3 months)</td>
<td>Lower infection and dysfunction rates compared to catheters</td>
<td>May be associated with primary maturation failure and subsequent need for additional procedures</td>
</tr>
<tr>
<td></td>
<td>Centrifugal or filter based TA</td>
<td>Most AVGs may be used within 2 weeks of placement</td>
<td>Requires trained staff for cannulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Requires surgery</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Requires trained staff for cannulation</td>
</tr>
</tbody>
</table>
# Vascular Access in Therapeutic Apheresis: Update 2013

Ladan Golestaneh and Michele H. Mokrzycki

Division of Nephrology, Department of Medicine, Albert Einstein College of Medicine, Bronx, New York

## TABLE I. Vascular Access Type Reported in the International Apheresis Registry, 2007

<table>
<thead>
<tr>
<th>Access Type</th>
<th>Europe (%)</th>
<th>Australia (%)</th>
<th>Asia (%)</th>
<th>North America (%)</th>
<th>Central and South America (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral veins</td>
<td>77</td>
<td>60</td>
<td>15</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Central vein</td>
<td>16</td>
<td>37</td>
<td>84</td>
<td>91</td>
<td>98</td>
</tr>
<tr>
<td>AVF/AVG</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>–</td>
</tr>
</tbody>
</table>

Malchesky et al. Ther Apher Dial 14(1), 2010 (Ref. 4). AVF, arteriovenous fistula; AVG, arteriovenous graft.

## TABLE II. Treatment Number and Type Reported in the International Apheresis Registry, 2007

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Europe (%)</th>
<th>Australia (%)</th>
<th>Asia (%)</th>
<th>North America (%)</th>
<th>Central and South America (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1–5</td>
<td>58</td>
<td>41</td>
<td>81</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>6–10</td>
<td>22</td>
<td>18</td>
<td>15</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>&gt;10</td>
<td>20</td>
<td>41</td>
<td>4</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPE</td>
<td>72</td>
<td>60</td>
<td>46</td>
<td>38</td>
<td>19</td>
</tr>
<tr>
<td>Plasma treatment</td>
<td>11</td>
<td>–</td>
<td>13</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Stem Cell Infusion</td>
<td>8</td>
<td>8</td>
<td>30</td>
<td>62</td>
<td>81</td>
</tr>
</tbody>
</table>

Malchesky et al. Ther Apher Dial 14(1), 2010.(ref. 4) TPE: Therapeutic Plasma Exchange.
Temporary & tunneled catheters for apheresis

- **Double-lumen hemodialysis catheters (partial list):**
  - Mahurkar, Quinton, Vas cath, Ash split cath (all temporary catheters)
  - Power trialysis temporary dialysis catheter (additional infusion port)
  - Hickman Apheresis tunneled CVC
  - PermCath tunneled CVC

- **Advantages of tunneled hemodialysis catheters:**
  - More secure, use for long-term apheresis (weeks-months)
  - Catheter lies flat (under clothing)
  - Line & skin infections: non-tunneled CVC > tunneled CVC >> AVF
  - Shower with exit site covered (once skin seals exit site); no immersing catheter exit site.
Placement of Apheresis CVCs

- **Anatomic locations:**
  - Most common choices: great vessels (chest); femoral veins
  - Right IJ > Left SC > Right SC > Left IJ
  - Catheter tip: junction of SVC and right atrium; proximal right atrium
  - Preparation (NPO for ≥8 hours)
  - Placement verification (fluoroscopy; CXR; ultrasound; TEE)

- **Who places apheresis CVCs:**
  - Interventional radiologists (IR suite: scheduled; weekend: emerg only)
  - Surgeons (OR suite; scheduled: often delayed due to other surgeries)
  - Intensivists (ICU; ultrasound guidance; may be faster than IR or OR)
  - Other (residents; nephrologists)
  - Tunneled CVCs (currently interventional radiologists or surgeons only)
Right Internal Jugular (IJ) Central Venous Access


Long-term tunneled central venous catheters often include a cuff (B) located just above (cephalad) to the skin exit site. The cuff facilitates tissue ingrowth over a two to three week period to anchor the catheter and minimize bacterial migration from the exit site.
### Advantages & Disadvantages of Central Vein Approaches For CVC Placement

<table>
<thead>
<tr>
<th>Approach</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| External jugular | - Superficial vessel that is often visible  
                  - Coagulopathy not prohibitive  
                  - Minimal risk of pneumothorax (especially with US guidance)  
                  - Head-of-table access  
                  - Prominent in elderly patients  
                  - Rapid venous access | - Not ideal for prolonged transvenous access  
                          - Poor landmarks in obese patients  
                          - High rate of malposition  
                          - Catheter may be difficult to thread |
| Internal jugular | - Minimal risk of pneumothorax (especially with US guidance)  
                           - Head-of-table access  
                           - Procedure-related bleeding amenable to direct pressure  
                           - Lower failure rate with novice operator  
                           - Excellent target using US guidance | - Not ideal for prolonged access  
                          - Risk of carotid artery puncture  
                          - Uncomfortable  
                          - Dressings and catheter difficult to maintain  
                          - Thoracic duct injury possible on left  
                          - Poor landmarks in obese/edematous patients  
                          - Potential access and maintenance issues with concomitant tracheostomy  
                          - Vein prone to collapse with hypovolemia  
                          - Difficult access during emergencies when airway control is being established |
| Subclavian     | - Easier to maintain dressings  
                  - More comfortable for patient  
                  - Better landmarks in obese patients  
                  - Accessible when airway control is being established | - Increased risk of pneumothorax  
                          - Procedure-related bleeding less amenable to direct pressure  
                          - Decreased success rate with inexperience  
                          - Longer path from skin to vessel  
                          - Catheter malposition more common (especially right SCV)  
                          - Interference with chest compressions |
| Femoral        | - Rapid access with high success rate  
                  - Does not interfere with CPR  
                  - Does not interfere with intubation  
                  - No risk of pneumothorax  
                  - Trendelenburg position not necessary during insertion | - Delayed circulation of drugs during CPR  
                          - Prevents patient mobilization  
                          - Difficult to keep site sterile  
                          - Difficult for PA catheter insertion  
                          - Increased risk of iliofemoral thrombosis |

**US**: ultrasound; **SCV**: subclavian vein; **CPR**: cardiopulmonary resuscitation; **PA**: pulmonary artery.

Inpatient care (for nurses):

- **Intra-luminal catheter-locking agents (port patency):**
  - Heparin: usually 1000-5000 U/ml (total of 5-6 ml)
    - Studies using 100U/ml: 10,000 U/ml
  - Citrate (4%)(5, 30, 47%): similar efficacy; ↓ bleeding risk & cost; no risk of HIT
  - rt-PA (recombinant tissue plasminogen activator)
  - Tego caps (non-heparin)

- **Dressing changes:**
  - usually after each treatment
  - antiseptic technique (mask, etc)
  - protection of line

Outpatient care (for patients):

- Temporary lines (keep dressing dry/no showers; care with dislodging line)
- Tunneled lines (first 2-3 weeks: keep dressing dry/no showers)
- Monitoring for site infection
- Compliance with catheter flush schedule

2-yr retrospective cohort study of heparin (100U/ml) vs citrate (4%) catheter locks:
- 84 pts, 554 PE txs examined
- Not RCT: 33% (citrate grp), 67% (heparin)

Results:
- Catheter flow problems (minor + severe):
  6.5% (citrate grp) vs 3.2% (heparin) \( p=0.11 \).
- Severe catheter flow problems:
  3.2% (citrate grp) vs 1.3% (heparin) \( p=0.11 \).
- Catheter infections:
  1.6% (citrate grp) vs 1.3% (heparin) \( p=0.53 \).
Citrate Versus Heparin for Apheresis Catheter Locks: An Efficacy Analysis

Bindu A. Passero,* Paula Zappone, Herma E. Lee, Cindy Novak, Erica L. Maceira, and Martha Naber

**Fig. 3.** Flow problems stratified by presence of MG diagnosis. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

<table>
<thead>
<tr>
<th>Lock Solution (number of treatments)</th>
<th>Flow Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrate (n=183)</td>
<td></td>
</tr>
<tr>
<td>Myasthenia Gravis (n=72)</td>
<td>10 (13.9%)</td>
</tr>
<tr>
<td>Other Diagnoses (n=111)</td>
<td>2 (1.8%)</td>
</tr>
<tr>
<td>Heparin (n=371)</td>
<td></td>
</tr>
<tr>
<td>Myasthenia Gravis (n=107)</td>
<td>6 (5.6%)</td>
</tr>
<tr>
<td>Other Diagnoses (n=264)</td>
<td>6 (2.3%)</td>
</tr>
</tbody>
</table>

**Fig. 4.** Catheter infections. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

<table>
<thead>
<tr>
<th></th>
<th>Citrate Treatments (%)</th>
<th>Heparin Treatments (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line infection</td>
<td>3 (1.6)</td>
<td>5 (1.3)</td>
</tr>
<tr>
<td>requiring catheter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>exchange</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table:** Flow Problems among Citrate Treatments

- MG (n = 179 Tx's)
- Non-MG (n = 375 Tx's)

- **p < 0.001**
- **p = 0.002**
- **p = 0.11**
- **p = 0.53**
RCT (of catheter-locking solutions):
- Heparin (5000U/ml) 3X/wk. vs rt-PA (1 mg) 1X/wk. + heparin 2X/wk.
- Tunneled CVC (HD pts, 6 months)
- 1º outcome: catheter malfunction
- 2º outcome: catheter-related infection

Results:
- Adverse events (table 2): no difference
- Catheter malfnc: 34.8% (heparin group) vs 20% (rt-PA group) (p=0.02).
- Catheter infx: 13% (heparin group) vs 4.5% (rt-PA group) (p=0.02).

Prevention of Dialysis Catheter Malfunction with Recombinant Tissue Plasminogen Activator

Brenda R. Hemmelgarn, M.D., Ph.D., Louise M. Moist, M.D., Charmaine E. Lok, M.D., Marcello Tonelli, M.D., S.M., Braden J. Manns, M.D., Rachel M. Holden, M.D., Martine LeBlanc, M.D., Peter Faris, Ph.D., Paul Barre, M.D., Jianguo Zhang, M.Sc., and Nairne Scott-Douglas, M.D., Ph.D., for the Prevention of Dialysis Catheter Lumen Occlusion with rt-PA versus Heparin (PreCLOT) Study Group

Figure 2. Kaplan–Meier Curves for the Time to Catheter Malfunction, According to Study Group.

The numbers in parentheses below the x axis are the numbers of patients in whom an episode of catheter malfunction occurred in the interval between follow-up assessments. The hazard ratio is for the group that received heparin as compared with the group that received recombinant tissue plasminogen activator (rt-PA).

Figure 3. Kaplan–Meier Curves for the Time to a First Episode of Bacteremia, According to Study Group.

The numbers in parentheses below the x axis are the numbers of patients in whom a first episode of catheter-related bacteremia developed in the interval between follow-up assessments. The hazard ratio is for the group that received heparin as compared with the group that received recombinant tissue plasminogen activator (rt-PA).
Traditional and non-traditional strategies to optimize catheter function: go with more flow

Michele H. Mokrzycki¹ and Charmaine E. Lok²

Excellent review:

Traditional and non-traditional strategies to optimize catheter function: go with more flow

Michele H. Mokrzycki¹ and Charmaine E. Lok²

¹Division of Nephrology, Department of Medicine, Montefiore Medical Center and Albert Einstein College of Medicine, Bronx, New York, USA and ²Division of Nephrology, Department of Medicine, Toronto General Hospital and University of Toronto, Toronto, Ontario, Canada

Table 2 | Summary of clinical trials using tPA for restoration of patency in hemodialysis catheters

<table>
<thead>
<tr>
<th>Medication</th>
<th>Protocol</th>
<th>No. of trials</th>
<th>Author, year (reference)</th>
<th>Short-term success</th>
<th>Long-term success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alteplase (1–2 mg)</td>
<td>Push</td>
<td>4</td>
<td>Meers, 1999⁸⁸ Spry, 2001ⁱ⁰² Eyrich, 2002⁹⁹ Zacharias, 2003¹⁰⁴</td>
<td>59–92%</td>
<td>60% Patency at 30 days</td>
</tr>
<tr>
<td>Reteplase (0.4 units/0.4 ml)</td>
<td>Short dwell (30 min ± an additional 30 min dose if needed)</td>
<td>6</td>
<td>Paulsen, 1993⁹⁶ Castner, 2001⁹³ O’Mara, 2003⁹¹ Nguyen, 2004⁹² Falk, 2004⁹⁴</td>
<td>69–97%</td>
<td>90-Day patency=53% (reteplase) Median days to next event =14 days (alteplase)</td>
</tr>
<tr>
<td>Alteplase (1–2 mg)</td>
<td></td>
<td></td>
<td>Hyman, 2004⁹⁶</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reteplase (0.5–3 units/lumen)</td>
<td>Long dwell (21–72 h)</td>
<td>7</td>
<td>Daeihagh, 2000⁹⁸ Savader, 2000⁹³ Little, 2002¹⁰¹ Hilleman, 2003⁹⁹ Nguyen, 2004⁹²</td>
<td>79–100%</td>
<td>90-Day patency=25–45% (alteplase or reteplase) Median days to next event =13–27 days (alteplase)</td>
</tr>
<tr>
<td>Alteplase (1–2.5 mg)</td>
<td></td>
<td></td>
<td>MacRae, 2005⁹⁷ Hamond, 2005¹⁰⁰</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenecteplase (2 mg/2 ml/lumen)</td>
<td>Short dwell (1 h dwell ± another 1 h dwell at next HD if needed) Short dwell (1 h dwell ± long dwell of 72 h if short dwell unsuccessful)</td>
<td>1</td>
<td>Tumlin, 2010¹²⁶</td>
<td>22% (short dwell)</td>
<td>If initial success occurred: 60% at third subsequent HD session (short dwell) 88% at third subsequent HD session (long dwell)</td>
</tr>
<tr>
<td>Placebo</td>
<td></td>
<td></td>
<td></td>
<td>40% (long dwell)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: HD, hemodialysis; tPA, tissue type-plasminogen activator.
Traditional and non-traditional strategies to optimize catheter function: go with more flow

Michele H. Mokrzycki\(^1\) and Charmaine E. Lok\(^2\)

\(^1\)Division of Nephrology, Department of Medicine, Montefiore Medical Center and Albert Einstein College of Medicine, Bronx, New York, USA and \(^2\)Division of Nephrology, Department of Medicine, Toronto General Hospital and University of Toronto, Toronto, Ontario, Canada

### Table 3 | Summary of clinical trials using FSS or FSD

<table>
<thead>
<tr>
<th>Author, year (reference)</th>
<th>FSS procedures (n)</th>
<th>Immediate technical/functional success</th>
<th>Primary patency post-procedure</th>
<th>Duration of additional catheter function</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crain, 1996(^{106})</td>
<td>40</td>
<td>100%/98%</td>
<td>45% at 3 months, 28% at 6 months</td>
<td>2.8 months</td>
<td>1 Femoral vein thrombus</td>
</tr>
<tr>
<td>Suhoki, 1996(^{27})</td>
<td>38</td>
<td>—/95%</td>
<td>Mean patency 3 months</td>
<td>20 days</td>
<td>None</td>
</tr>
<tr>
<td>Haskal, 1996(^{107})</td>
<td>24</td>
<td>92%/—</td>
<td>9% at 2 weeks</td>
<td></td>
<td>1 Paroxysmal supraventricular tachycardia</td>
</tr>
<tr>
<td>Rockall, 1997(^{108})</td>
<td>131</td>
<td>100%/79%</td>
<td>56% at 3 months, 46% at 6 months</td>
<td>4.25 months</td>
<td>2 Groin hematomas</td>
</tr>
<tr>
<td>Brady, 1999(^{109})</td>
<td>16</td>
<td>100%/—</td>
<td>40% at 6 months</td>
<td>4.2 months</td>
<td>None</td>
</tr>
<tr>
<td>Johnstone, 1999(^{110})</td>
<td>16</td>
<td>100%/—</td>
<td></td>
<td></td>
<td>3 Groin hematomas</td>
</tr>
<tr>
<td>Gray, 2000(^{111})</td>
<td>28</td>
<td>—/89%</td>
<td>52% at 1 month, 35% at 1.5 months</td>
<td>32 days</td>
<td>1 line infection after 1 week</td>
</tr>
<tr>
<td>Merport, 2000(^{112})</td>
<td>15</td>
<td>97%/—</td>
<td>31% at 1 month, 0 at 4 months</td>
<td>9 days</td>
<td>1 Innominate vein thrombus</td>
</tr>
<tr>
<td>D’Othee, 2006(^{113})</td>
<td>18</td>
<td>100%/—</td>
<td>72% at 1 month, 60% at 3 months</td>
<td>4.5 months</td>
<td>1 Groin hematomia</td>
</tr>
<tr>
<td>Catheter exchange ± FSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oliver, 2007(^{106})</td>
<td>18 +FSD/CEX</td>
<td>—</td>
<td>373 days +FSD/CEX, 97.5 days +FSD/CEX (P=NS)</td>
<td>411 days +FSD/CEX</td>
<td>+FSD/CEX: shortness of breath (n=1)</td>
</tr>
<tr>
<td></td>
<td>12 —FSD/CEX</td>
<td></td>
<td></td>
<td></td>
<td>bleeding (n=3)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>redness (n=2)</td>
</tr>
<tr>
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<td></td>
<td></td>
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<td>swelling (n=2)</td>
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<td></td>
<td></td>
<td>—FSD/CEX: bleeding (n=1); (P=NS)</td>
</tr>
</tbody>
</table>

Abbreviations: CEX, catheter exchange; FSD, fibrin sheath disruption; FSS, fibrin sheath stripping; NS, non-significant.

Management Strategies for CVC Dysfunction

- **Immediate and long-term strategies** (for CVC dysfunction):
  - Forceful saline flush and reversal of ports (~15% ↓ efficiency):
  - Re-positioning patient (ie, catheter port against vessel wall)
  - Thrombolytic agents (rTPA) may restore patency:
    - Short-term success: 22-100%
    - Long-term (90-day patency) rate: 25-53%
  - Mechanical disruption of fibrin sleeve or stripping (FSS):
    - Immediate patency rate: 79-98%
    - Long term (3-month) patency (after FSS): 45-60%
    - Complications: groin hematomas, infection, & venous thrombosis
  - Tunneled catheter exchange over a guidewire (after failed TPA):
    - Primary patency (@ 3 months): 51%; @ 6 months: 37%
    - Low complication rates

Removal of Apheresis CVCs

• **Inpatient care** (for physicians):
  • Removal of temporary internal jugular or subclavian CVCs:
    • Apheresis CVC usually removed by physician (or PA or NP)
    • Patient supine or semi-recumbent position
    • Remove sutures (usually 2) securing line
    • Remove line with continuous motion as patient exhales with sterile gauze immediately placed over exit site (usually folded 4x4 inch gauze).
    • Apply firm pressure on gauze for 10-15 minutes, then place 1-1.5 inch wide plastic tape over gauze (forming type of pressure dressing).

• **Outpatient care** (for patients, of exit site):
  • Keep pressure dressing on exit site for up to 24 hours (no shower)
  • After 24 hours, remove dressing (apply large band-aid to exit site every 24 hours after showering for up to 7 days).
  • Monitor for exit site infection (fever/chills/systemic symptoms; localized pain; heat; redness; drainage; etc); if discovered, call MD immediately.
Vascular Access Complications
(associated with CVCs placed for apheresis procedures)

Overall – 0-4% of all CVC placement procedures (for apheresis):

• **Site inflammation (or infection)**
• **Line infection:**
  • Occult bacteremia to septicemia
  • Signs/symptoms include (partial list):
    • Fever >38.0 C
    • Atrial tachyarrhythmias; hypotension; rigors; CNS changes; etc
• **Pneumothorax** (rare; noticeable during or slightly after line placement, or incidentally):
  • Confirmed by CXR; may (or may not) require chest tube
• **Line migration**
• **Hematoma** (slightly greater occurrence when pts on anticoagulation therapy)
• **Thrombosis**
## Complications of Apheresis

**Andre Kaplan**  
Division of Nephrology, University of Connecticut Health Center, Farmington, Connecticut

### TABLE 1. Complications of apheresis

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urticaria</td>
<td>0.7–12</td>
</tr>
<tr>
<td>Paresthesias</td>
<td>1.5–9</td>
</tr>
<tr>
<td>Muscle cramps</td>
<td>0.4–2.5</td>
</tr>
<tr>
<td>Dizziness</td>
<td>&lt;2.5</td>
</tr>
<tr>
<td>Headaches</td>
<td>0.3–5</td>
</tr>
<tr>
<td>Nausea</td>
<td>0.1–1</td>
</tr>
<tr>
<td>Hypotension</td>
<td>0.4–4.2</td>
</tr>
<tr>
<td>Chest pain</td>
<td>0.03–1.5</td>
</tr>
<tr>
<td>Dysrhythmia</td>
<td>0.1–0.7</td>
</tr>
<tr>
<td>Anaphylactoid reactions</td>
<td>0.03–0.7</td>
</tr>
<tr>
<td>Rigors</td>
<td>1.1–8.8</td>
</tr>
<tr>
<td>Hyperthermia</td>
<td>0.7–1.0</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>0.1–0.4</td>
</tr>
<tr>
<td>Seizure</td>
<td>0.03–0.4</td>
</tr>
<tr>
<td>Respiratory arrest/pulmonary edema</td>
<td>0.2–0.3</td>
</tr>
<tr>
<td>Myocardial ischemia</td>
<td>0.1</td>
</tr>
<tr>
<td>Shock/myocardial infarction</td>
<td>0.1–1.5</td>
</tr>
<tr>
<td>Metabolic alkalosis</td>
<td>0.03</td>
</tr>
<tr>
<td>Disseminated intravascular coagulation</td>
<td>0.03</td>
</tr>
<tr>
<td>Central nervous system ischemia</td>
<td>0.03–0.1</td>
</tr>
<tr>
<td>Hepatitis</td>
<td>0.7</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>0.2</td>
</tr>
<tr>
<td>Hypoxemia</td>
<td>0.1</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Access related**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrombosis/hemorrhage</td>
<td>0.02–0.7</td>
</tr>
<tr>
<td>Infection</td>
<td>0.3</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0.1</td>
</tr>
<tr>
<td>Mechanical</td>
<td>0.08–4</td>
</tr>
</tbody>
</table>


Kaplan A. Seminars in Dialysis 2012; 25 (2): 152-158.
## Complications of CVC

<table>
<thead>
<tr>
<th>Complications of central venous catheterization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Immediate</strong></td>
</tr>
<tr>
<td>Bleeding</td>
</tr>
<tr>
<td>Arterial puncture</td>
</tr>
<tr>
<td>Arrhythmia</td>
</tr>
<tr>
<td>Air embolism</td>
</tr>
<tr>
<td>Thoracic duct injury (with left SC or left JJ approach)</td>
</tr>
<tr>
<td>Catheter malposition</td>
</tr>
<tr>
<td>Pneumothorax or hemothorax</td>
</tr>
<tr>
<td><strong>Delayed</strong></td>
</tr>
<tr>
<td>Infection</td>
</tr>
<tr>
<td>Venous thrombosis, pulmonary emboli</td>
</tr>
<tr>
<td>Catheter migration</td>
</tr>
<tr>
<td>Catheter embolization</td>
</tr>
<tr>
<td>Myocardial perforation</td>
</tr>
<tr>
<td>Nerve injury</td>
</tr>
</tbody>
</table>

Research

Central venous catheter-related infection in a prospective and observational study of 2,595 catheters
Leonardo Lorente¹, Christophe Henry¹, María M Martín¹, Alejandro Jiménez² and María L Mora¹

Table 1

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of CVCs</th>
<th>Days of CVC</th>
<th>Number of CRLIs</th>
<th>ID of CRLIs</th>
<th>% CVC with CRLI</th>
<th>Number of CRBSIs</th>
<th>ID of CRBSIs</th>
<th>% CVC with CRBSIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subclavian</td>
<td>917</td>
<td>8,239</td>
<td>13</td>
<td>1.57</td>
<td>1.42%</td>
<td>8</td>
<td>0.97</td>
<td>0.87%</td>
</tr>
<tr>
<td>Jugular</td>
<td>1,390</td>
<td>8,361</td>
<td>64</td>
<td>7.65</td>
<td>4.60%</td>
<td>25</td>
<td>2.99</td>
<td>1.80%</td>
</tr>
<tr>
<td>Femoral</td>
<td>288</td>
<td>2,399</td>
<td>38</td>
<td>15.83</td>
<td>13.19%</td>
<td>20</td>
<td>8.34</td>
<td>6.94%</td>
</tr>
<tr>
<td>Total</td>
<td>2,595</td>
<td>18,999</td>
<td>115</td>
<td>6.05</td>
<td>4.43%</td>
<td>53</td>
<td>2.79</td>
<td>2.04%</td>
</tr>
</tbody>
</table>

CRBSI, catheter-related bloodstream infection; CRLI, catheter-related local infection; CVC, central venous catheter; ID, incidence density defined as number of infections per 1,000 catheter-days.

Table 2

Comparison of catheter-related local infection incidence densities between different central venous sites

<table>
<thead>
<tr>
<th></th>
<th>ID</th>
<th>OR (95% CI)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral versus jugular</td>
<td>15.83 vs 7.65</td>
<td>2.1 (1.35–3.14)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Femoral versus subclavian</td>
<td>15.83 vs 1.57</td>
<td>3.2 (2.29–4.53)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Jugular versus subclavian</td>
<td>7.65 vs 1.57</td>
<td>4.8 (2.64–9.60)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

CI, confidence interval; ID, incidence density defined as number of infections per 1,000 catheter-days. OR, odds ratio.

Table 3

Comparison of catheter-related bloodstream infection incidence densities between different central venous sites

<table>
<thead>
<tr>
<th></th>
<th>ID</th>
<th>OR (95% CI)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral versus jugular</td>
<td>8.34 vs 2.99</td>
<td>2.8 (1.46–5.22)</td>
<td>0.002</td>
</tr>
<tr>
<td>Femoral versus subclavian</td>
<td>8.34 vs 0.97</td>
<td>2.9 (1.90–4.75)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Jugular versus subclavian</td>
<td>2.99 vs 0.97</td>
<td>3.1 (1.34–7.90)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

CI, confidence interval; ID, incidence density defined as number of infections per 1,000 catheter-days. OR, odds ratio.
Peripheral Access for WBC Collection:  
*Pre-treatment Evaluation (including vein check)*

- **Past medical history:** prior cardiac, pulmonary, or kidney disease, cancer or autoimmune disease, or coagulopathy (h/o DVT, PE, or bleeding); any recent infections, hospitalizations, surgeries; any reason patient cannot lie semi-recumbent.
- **List of current medications**
- **Allergies to medications**
- **Vascular access:** evaluate/document patient’s antecubital and forearm veins for adequate vascular access; may need temporary CVC.
- **General lab tests (pre-treatment):** CBC, chem 7, Ca++, Mg++; baseline albumin; PT/INR/fibrinogen.
Patient Preparation is Key
(for maintaining peripheral access during long TA procedure)

- **2-3 days before scheduled procedure:**
  - Hydrate (water >> juice) for 72 hours prior to scheduled procedure
  - Avoid strenuous exercise, alcohol, diuretics, or caffeinated drinks or food for 48-72 hours prior to procedure.
  - Get plenty of sleep (>7-8 hours/night); attempt to maintain low stress environment.
  - Hydration “app” (text messages Q 6 hours X 72 hours)

- **Day of procedure:**
  - Eat breakfast (no coffee, minimal fluids) the morning of procedure
  - Hold morning medications (esp. BP meds); bring all meds to clinic
  - Wear loose, comfortable clothing
  - Distractions (DVDs, audio CDs, supportive friend); conscious relaxation
Vascular Access (outpatient WBC collections)

- **Obtaining peripheral access:**
  - Skill of RN is paramount (vein choice, access skills, warming extremity)
  - Access (16-17 gauge steel needle, antecubital vein, ID lidocaine)
  - Return (18-20 gauge angiocath, non-antecubital vein, ID lidocaine)

- **Maintaining peripheral access** (throughout the procedure):
  - Skill of RN (vein choice, access skills, keeping patient engaged & warm)
  - Patient preparation, hydration, and ability to comply with protocol;
    IV hydration (200-1000 ml NS over 30-90 minutes) may be helpful.
  - Hot packs (pre-warming access site; patient squeezing pack during tx)
  - Positioning (keeping “access” arm externally rotated to maintain flow)
  - IV start: cuff pressure 20-30 mm Hg > DBP (~100 mm Hg); ↓ to 40 mm Hg
  - WB:AC = 12:1 (9:1-14:1)
  - Vascular spasm (autonomic control)
  - ↑↑ pressure alarms or loss of interface → ↑↑ RBC contamination

- **Monitoring for citrate toxicity** (paresthesias, vibratory sensation, etc)
Vascular Access
(outpatient WBC collections)

- **After procedure care** (to minimize swelling, tenderness, & bruising):
  - Rest, drink extra fluids (non-alcoholic), eat well, avoid stressful work
  - Keep sites dry, avoid exercise or heavy lifting for 1-2 days
  - Leave the pressure dressing in place for 4-8 hours (replace daily with large band-aid for the next 4-7 days).
  - Apply ice intermittently (up to 5-10 minutes TID-QID) for first 1-3 days to needle sites.
  - Consider OTC NSAID medication (w/food) PRN soreness
  - If bleeding at needle site occurs, apply direct pressure with clean cloth and elevate extremity.
  - Contact MD if fever or chills develop, dizziness occurs, etc

- **Post-central line care** (discussed earlier):
  - Managing pressure dressing, monitoring for exit site infection, etc
Venous Access for IV Contrast

- No decision flowchart available for choosing most appropriate venous access for different types of TA.
Main Determinants of Vascular Access for TA

- **Type of TA procedure:**
  - Cytapheresis for hyperleukocytosis or thrombocytosis often done daily in patients with cellular hyperviscosity require CVC (peripheral access is not appropriate).

- **Type of TA system used:**
  - CVC or AVF necessary when using membrane-based system whereas peripheral access may be appropriate when using centrifugation-based system.

- **Acuity, number, and frequency of treatments needed:**
  - 5-7 daily (or QOD) treatments best managed with a temporary CVC (esp. inpatient)
  - 1-3 treatments (over 1-2 weeks) may be manageable with peripheral access

- **Anticipated duration of treatment:**
  - If duration of treatment (DOT) > 3-4 weeks, tunneled CVC is usually most appropriate
  - If DOT > 4-6 months, AVF, possibly AVG, or implantable port is most appropriate

- **Patient’s vascular anatomy, mobility, and hygiene**
- **Location of treatment** (inpatient versus outpatient)
- **Experience/comfort level of providers** (with different types of vascular access):
  - CVC for access used in 77% cases in N. America
  - Peripheral access much more commonly used in Europe, Asia, and Australia

Power Hickman CVCs

Characteristics:
- 9.5 Fr tunneled catheter (for adults)
- Maximum flow rates (~80 ml/min)
  (Manufacturer: maximum flow rate of 5 mL/sec)
- Catheter locking: 100U/ml daily (~3 ml/lumen)

[Data from single institution use]

Courtesy of Adelle Ulner, RN, HP (Stanford University)
Insyte Angiocath (for peripheral IV access)

For peripheral access & return:
- To replace steel needle (esp. with prior thrombosis).
- Flow rates: 40-50 ml/min (with 18 G angiocath).
- Use AC vein (or non-AC vein in forearm).
- May use 20 G angiocath (for return; minimal high pressure alarms).
- Works well for ECP txs

Courtesy of Adelle Ulner, RN, HP (Stanford University)
Conclusions / Summary

- Main determinants of vascular access for TA depend on type of procedure; acuity; number, frequency, and anticipated duration of treatment; patient’s vascular anatomy; and providers’ comfort level.

- Catheter locking agents other than heparin (such as citrate and rt-PA) are showing similar efficacy and safety.

- Maintaining peripheral access (especially for lengthy TA procedures, such as WBC collections) depend on patient hydration, RN venous access skills, and vein selection and management.

- New devices for central venous and peripheral access are providing greater choice in technology and improving ease of use and less exposure to locking anticoagulants.

- North and South America have a significantly greater use of CVCs (and less use of peripheral vascular access) compared to Europe and Australia.
Selected References

Kaplan A.  Seminars in Dialysis 2012; 25 (2): 152-158.
Thank you for your attention