Reaching New Heights in Understanding Central Venous Catheter Thrombosis

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Top 4 Things to Know for CE

1. Make sure your BADGE IS SCANNED each time you enter a session to record your attendance.

2. Carry your Evaluation Packet with you to EVERY session.

3. Pharmacists, Pharmacy Technicians and Nurses need to track their hours on the Statement of Continuing Education Form as they go (*the 2-page triplicate form, so press firmly!*).

4. FOR CE: At your last session, total the hours and sign both pages of your Statement of Continuing Education Form.
   - Keep the PINK copy for your records and place the YELLOW and WHITE copies in your CE Envelope.
   - Make sure an Evaluation Form is in your CE Envelope for each session you attended (*extra forms are available at the registration desk if you forgot to pick one up).*
   - Write your name and unique ID number (*six digit number at the bottom of your name badge*) in the designated area on the outside of the envelope, seal it, and place it in the drop box located near the registration area.
• Lynn Manly is Clinical Director for Navilyst Medical. The conflict of interest was resolved by peer review of slide content.

• Elected – Nominations and Bylaws Committee, Association for Vascular Access. Chair

• This content has been previously presented at the Infusion Nurses Society Gateway Chapter Meeting on August 24, 2011, in St. Louis, MO.

• Clinical trials and off-label/investigational uses will not be discussed during this presentation.
Objectives

• Identify 3 central venous catheter (CVC) related complications
• Recognize the prevalence and clinical relevance of 3 CVC-related complications
• Examine in-depth details of CVC-related thrombosis
• Distinguish varying methods of managing catheter-related thrombosis
Complications of Central Venous Catheters (CVCs)
Catheter-Related Infections

There are three types of CR-Infections

• Bloodstream infection (BSI)
  – Sepsis or bacteremia
• Catheter colonization
• Exit-site infection
Catheter-Related Bloodstream Infections$^{1,2,3}$

Prevalence and Relevance

$>5,000,000$ Patients each year in U.S. with a central venous catheter$^1$

$\sim250,000$ Bloodstream infections each year$^3$

$\sim30-60,000$ Attributable mortality annually$^2$
How Often Do PICCs Cause CR-BSIs? Prevalence and Relevance

Approximately .5 – 2.2% of PICCs have CR-BSIs (per 100 catheters)

Table 1: Rates of bloodstream infection (BSI) caused by various types of devices used for vascular access.

<table>
<thead>
<tr>
<th>Device</th>
<th>No. of prospective studies</th>
<th>Pooled mean</th>
<th>95% CI</th>
<th>Pooled mean</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral venous catheter</td>
<td>13</td>
<td>0.2</td>
<td>0.1–0.3</td>
<td>0.6</td>
<td>0.3–1.2</td>
</tr>
<tr>
<td>Arterial catheter</td>
<td>6</td>
<td>1.5</td>
<td>0.9–2.4</td>
<td>2.9</td>
<td>1.8–4.5</td>
</tr>
<tr>
<td>Short-term, nonmedicated CVC</td>
<td>61</td>
<td>3.3</td>
<td>3.3–4.0</td>
<td>2.3</td>
<td>2.0–2.4</td>
</tr>
<tr>
<td>Pulmonary-artery catheter</td>
<td>12</td>
<td>1.9</td>
<td>1.1–2.5</td>
<td>5.5</td>
<td>3.2–12.4</td>
</tr>
<tr>
<td>Hemodialysis catheter Noncuffed</td>
<td>15</td>
<td>16.2</td>
<td>13.5–18.3</td>
<td>2.8</td>
<td>2.3–3.1</td>
</tr>
<tr>
<td>Hemodialysis catheter Cuffed</td>
<td>5</td>
<td>6.3</td>
<td>4.2–9.2</td>
<td>1.1</td>
<td>0.7–1.6</td>
</tr>
<tr>
<td>Peripherally inserted central catheter</td>
<td>8</td>
<td>1.2</td>
<td>0.5–2.2</td>
<td>0.4</td>
<td>0.2–0.7</td>
</tr>
<tr>
<td>Long-term tunneled and cuffed CVC</td>
<td>18</td>
<td>20.9</td>
<td>18.2–21.9</td>
<td>1.2</td>
<td>1.0–1.3</td>
</tr>
<tr>
<td>Subcutaneous central venous port</td>
<td>13</td>
<td>5.1</td>
<td>4.0–6.3</td>
<td>0.2</td>
<td>0.1–0.2</td>
</tr>
</tbody>
</table>
Catheter-Related Thrombotic Occlusions
Catheter-Related Occlusions$^{5,7,8}$

Prevalence and Relevance

• Most common non-infectious complication in the long-term use of CVCs, and in particular, PICCs$^{5,7}$

• Approximately 1 in 4 CVCs may become occluded$^8$

• Occlusions may present as:
  – Partial or complete
  – Thrombotic or non-thrombotic
  – Intraluminal or extraluminal
How Do YOU Determine Occlusion?7

Prevalence and Relevance
Potential indicators of catheter occlusion7

✓ Inability to infuse fluids
✓ Lack of free-flowing blood return
✓ Increased resistance when flushing
✓ Sluggish flow
✓ Frequent infusion pump alarms

Learn what YOUR prevalence and relevance are!
CVC-Related Occlusions$^{7,8}$

- Non-Thrombotic Occlusions
  - Mechanical
  - Lipid or chemical aggregation
  - Precipitate
- Thrombotic Occlusions
  - Intraluminal
    - Thrombus
  - Extrapoluminal
    - Fibrin sheath
    - Mural thrombosis

Prevalence and Relevance

How Do Thrombotic Occlusions Form?\textsuperscript{4,12}

**EXAMPLE OF FIBRIN FORMATION**-

- Proteins bind to surface
  ![Proteins bind to surface](image)

- Platelets and white cells adhere to proteins
  ![Platelets and white cells adhere to proteins](image)

- Fibrinous sheath forms, 1 mm thickness within 24 hrs\textsuperscript{12}
  ![Fibrinous sheath forms](image)
What Role do Fibrin Sheaths Play in Thrombosis?\textsuperscript{4,9,12}

Fibrin sheaths may be linked to thrombus development

• Development of sheath usually begins with endothelial injury (such as surgery, IV or CVC insertion) and localized thrombosis, followed by deposition of plasma proteins along the catheter wall and an inflammatory response with proliferation of smooth muscle, fibroblasts, and endothelial cells

• All catheters develop a fibrin sheath upon insertion

• Presence of a fibrin sheath alone may not be sufficient to cause either thrombosis or bloodstream infection

• May serve as the foundation for thrombus development\textsuperscript{12}
Intraluminal Thrombotic Occlusions\textsuperscript{4,7,13}

- Fibrin accumulation can initiate inside the catheter tip and is often the result of blood reflux into the catheter\textsuperscript{7,13}
• Fibrin formation may lead to a fibrin sheath or flap\textsuperscript{12}
Fibrin Sheath
Intraluminal Thrombus
Catheter-Related Deep Vein Thrombosis (CR-DVT)
Deep Vein Thrombosis Awareness\textsuperscript{10,11}

Prevalence and Relevance

• Each year 200,000-600,000 Americans suffer from Venous Thromboembolism (VTE), which includes Deep Vein Thrombosis (DVT) and Pulmonary Embolism (PE)\textsuperscript{11}

• At least 100,000 deaths per year are directly related to VTE\textsuperscript{10}

• VTE is the leading cause of preventable, in-hospital deaths affecting more people annually than highway fatalities, breast cancer and AIDS combined\textsuperscript{10}

• \textit{74\% of people surveyed have little or no awareness of DVT symptoms}\textsuperscript{11}
Correlation Between Infection, Occlusion and DVTs\textsuperscript{4,20,32}

Infection is linked to occlusion and DVT\textsuperscript{4,32}

- CVC placement provides a rich culture for bacterial growth because of foreign body response upon insertion of CVC
  - Biofilm layer develops that encloses and protects bacteria, which can lead to infection
- Post-mortem evaluation of 72 cancer patients with CVCs showed a strong correlation between CR-sepsis and CVC thrombosis
  - Fibrin layer present on ALL catheters
  - CR-Thrombosis present in 38% of cases**
    - ** 23% of these had sepsis
    - ** No patients without thrombosis had sepsis
Venous Thrombosis Risks

**Patient and Vascular**
- Catheter-associated infection
- Fibrinous catheter lumen occlusion
- Extrinsic vascular compression
- Age extreme (old/young)

**Technical**
- Larger catheter diameter
- Multi-lumen catheters
- Catheter tip malposition
- Two or more insertion attempts
- Left-sided placement
- Subclavian vein insertion

**Treatment-Related**
- L-asparaginase
- Estrogen or progesterone agents
- Recombinant human Interleukin-2
- Granulocyte-macrophage CSF
- Thalidomide
Catheter-Related Venous Thrombosis\textsuperscript{33,34}

If a CR-Venous Thrombus develops, between the catheter and vessel wall, it may:

- Lead to complete blockage of the vein
- Be a life-threatening condition
- Have potential complications including, but not limited to, pulmonary embolism
Types of Upper Extremity DVT

Approximately 10% of all DVT involve upper extremities (UEDVT)

• Primary (20%)
  – Venous thoracic outlet syndrome
  – Effort-related thrombosis (Paget-Schroetter syndrome)
  – Idiopathic

• Secondary (80%)
  – Catheter-related thrombosis
  – Cancer-associated thrombosis
  – Surgery or trauma of the arm or shoulder
  – Hormone–induced coagulation abnormalities (i.e. pregnancy)
PICC-Related DVT Incidence Rates

Prevalence and Relevance

• Symptomatic PICC related DVTs
  • 1-4% incidence

• Asymptomatic + symptomatic PICC related DVTs
  • Up to 38% incidence

• Median time to thrombus: 8 to 12 days
Known Sequelae of UEDVT$^{23,28}$

- **Pulmonary embolism$^{23}$**
  - Occurs in approximately 6% of patients

- **Post-thrombotic syndrome$^{28}$**
  - Pain on standing
  - Limb edema
  - Lipodermatosclerosis
  - Skin changes (ulcers, eczema)
  - Secondary, superficial varicose veins
  - Non-specific: clinical conditions other than DVT may result in similar symptoms

- **SVC Syndrome**
Risk Factors for CR-UEDVT \textsuperscript{17,19, 25,26,27}

- Prior DVT\textsuperscript{25}
- Catheter Diameter\textsuperscript{25,26}
  - Increased incidence of thrombosis with larger diameter catheters/smaller vessels (e.g., cephalic)
- Hypercoagulability/ Anti-coagulant use\textsuperscript{17,27}
- Surgery Duration > 1 hour\textsuperscript{25}
- PICC Duration/Length of Stay\textsuperscript{25}
- Male Gender\textsuperscript{19}

Symptomatic DVT Rates

\begin{figure}
\centering
\includegraphics[width=\textwidth]{dvt_rates}
\caption{Evans et. al CHEST 2010}
\end{figure}
Inherent CVC-Related Risk Factors for DVT$^{14,16}$

- Virchow’s Triad illustrates the inherent risk factors that present with CVC placement, predisposing a patient to DVT$^{14,16}$
  1. Vessel wall injury
  2. Stasis
  3. Hypercoagulable state
• The endothelium is the thin layer of cells forming an interface between circulating blood in the lumen and the rest of the vessel wall. The endothelium provides a non-thrombogenic surface.

• Disruptions in the endothelium may cause the thrombin cascade to become activated.

• PICC placement may cause a disruption to the endothelium.
  – 21 G needle puncture (sometimes double wall)
  – Wire and sheath/ dilator trauma
  – Irritation caused by indwelling PICC
The “tools” for PICC insertions can be a part of the ‘issue’
Damage (thrombus, fibrosis) to cephalic vein due to previous PICC
Stenosis and thrombosis of cephalic vein due to PICC
Why is Stasis a Risk for VT?

Understanding Stasis and Poiseuille’s Law - *Mathematical equation related to fluid flow and hemodynamics (blood flow)*

- Fluid movement within a tube – movement near the edge moves slowly due to friction
- Fluid movement near center of the tube (vessel) moves more quickly
- A CVC displaces some of the faster-moving blood AND creates turbulence
- A CVC also provides additional friction due to its own surface area
- **Overall flow is reduced and a level of stasis results**
How are Devices Related to Venous Stasis?20

• PICC French size may contribute to venous stasis
• Smaller devices in larger vessels are less likely to causes venous stasis

<table>
<thead>
<tr>
<th>Vein</th>
<th>Initial Flow</th>
<th>2 Fr</th>
<th>4 Fr</th>
<th>6 Fr</th>
<th>8 Fr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalic</td>
<td>5</td>
<td>2.8</td>
<td>56%</td>
<td>2.1</td>
<td>41%</td>
</tr>
<tr>
<td>Brachial</td>
<td>5</td>
<td>2.8</td>
<td>56%</td>
<td>2.1</td>
<td>41%</td>
</tr>
<tr>
<td>Basilic</td>
<td>15</td>
<td>9.2</td>
<td>61%</td>
<td>7.2</td>
<td>48%</td>
</tr>
<tr>
<td>Axillary</td>
<td>250</td>
<td>173</td>
<td>69%</td>
<td>153</td>
<td>61%</td>
</tr>
<tr>
<td>Subclavian</td>
<td>500</td>
<td>355</td>
<td>71%</td>
<td>315</td>
<td>63%</td>
</tr>
</tbody>
</table>
## Defects Responsible for Hypercoagulability

<table>
<thead>
<tr>
<th>Inherited</th>
<th>Acquired</th>
<th>Non-Coagulant Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Activated protein C resistance</td>
<td>• Antiphospholipid syndrome</td>
<td>• Malignancy</td>
</tr>
<tr>
<td>• Protein S deficiency</td>
<td>• Hyperhomocysteinemia</td>
<td>• Pregnancy</td>
</tr>
<tr>
<td>• Protein C deficiency</td>
<td>• Thrombocytopenia</td>
<td>• Bed rest</td>
</tr>
<tr>
<td>• Hyperhomocysteinemia</td>
<td>• Dysproteinemia</td>
<td>• Surgery</td>
</tr>
<tr>
<td>• Prothrombin 20210A allele</td>
<td>• HIT</td>
<td>• Trauma</td>
</tr>
<tr>
<td>• Dysplasminogenemia</td>
<td>• Estrogens</td>
<td></td>
</tr>
<tr>
<td>• High plasminogen activator inhibitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Dysfibrinogenemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Elevated factor VIII</td>
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</table>
CHEST Guidelines: Management of Acute Upper Extremity DVT
Managing Catheter-Related Thrombosis – Clinical Review

Clinical Practice Guidelines

Antithrombotic Therapy for Venous Thromboembolic Disease*

American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th Edition)

Clive Kearon, MB, PhD; Susan R. Kahn, MD; Giancarlo Agnelli, MD; Samuel Goldhaber, MD, FCCP; Gary E. Raskob, PhD; and Anthony J. Comerota, MD
8.1 For patients with acute upper-extremity DVT we recommend initial treatment with therapeutic doses of low molecular weight heparin, unfractionated heparin, or fondaparinux, as described for leg DVT.
1.1.3. For patients with acute DVT, we recommend initial treatment with low molecular weight heparin, unfractionated heparin, or fondaparinux for at least 5 days and until the INR is > 2.0 for 24 h.

1.1.4. In patients with acute DVT, we recommend initiation of Coumadin™ together with LMWH, UFH, or fondaparinux on the first treatment day.
8.4.1. For patients with acute UEDVT, we recommend treatment with Coumadin™ for > 3 months.

8.4.3. For patients who have UEDVT in association with a central venous catheter that is removed, we do not recommend that the duration of long-term anticoagulant treatment be shortened to < 3 months.
8.6.1. In patients with UEDVT who have persistent edema and pain, we suggest elastic bandages or elastic compression sleeves to reduce symptoms of post-thrombotic syndrome of the upper extremity.
8.4.2. For most patients with UEDVT in association with a central venous catheter we suggest that the catheter not be removed if it is functional and there is an ongoing need for the catheter.
Summary of VT and DVT Management

• Guidelines and recommendations for VT and DVT management are available, but it is critical to consider each patient’s specific situation and treatment needs when determining management requirements.
  – Anticoagulant therapy
  – Thrombolytic therapy
  – Device management
    • Catheter maintenance, removal or re-placement
Heighten your DVT awareness related to your home infusion patients
UEDVT –
Time to Occurrence and Monitoring

• Most UEDVTs develop within the first 12 days post PICC placement
• Do not take blood pressures on PICC arm
• Assess the entire limb, not just the insertion site
• Assess the entire patient for s/s of UEDVT
# PICC-Related Thrombosis

<table>
<thead>
<tr>
<th>Study</th>
<th>Type</th>
<th>Type of Symptom</th>
<th>Detection</th>
<th>Thrombosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ng</td>
<td>Prospective</td>
<td>Symptomatic</td>
<td>Clinical with US Confirmation</td>
<td>1.6%</td>
</tr>
<tr>
<td>Grove</td>
<td>Retrospective</td>
<td>Presumed</td>
<td>Ultrasound</td>
<td>3.9%</td>
</tr>
<tr>
<td>Chemaly</td>
<td>Retrospective</td>
<td>Presumed</td>
<td>US or Venogram</td>
<td>2.5%</td>
</tr>
<tr>
<td>King</td>
<td>Retrospective</td>
<td>Symptomatic</td>
<td>Clinical with US Confirmation</td>
<td>2.0%</td>
</tr>
<tr>
<td>Cowl</td>
<td>Prospective (PICC vs. SC)</td>
<td>Symptomatic</td>
<td>Clinical with US Confirmation</td>
<td>7.8%</td>
</tr>
<tr>
<td>Gonsalves</td>
<td>Retrospective</td>
<td>Asymptomatic</td>
<td>US Central Veins Only</td>
<td>7.0%</td>
</tr>
<tr>
<td>Abdullah</td>
<td>Prospective</td>
<td>Asymptomatic</td>
<td>Venogram</td>
<td>38.5%</td>
</tr>
<tr>
<td>Allen</td>
<td>Retrospective</td>
<td>Asymptomatic</td>
<td>Venogram</td>
<td>23.3%</td>
</tr>
</tbody>
</table>
Summary

• Let this program be your stepping stone in heightening your awareness of DVTs and the relationship to PICCs
• Don’t stop here.....continue your quest.
• Teach others!
• Make this awareness your new mission in doing the right thing!
Learning Assessment Questions & Answers

Please refer to the NHIA Annual Conference & Exposition 2012 On-Site Program for a brief post-test.

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4/9/2012 50
Citations

15. JNCCN2006; 4:889-901.
Citations


20. Nifong, T., “Infection or clot – which comes first?”, 22nd Annual Scientific Meeting of the Association for Vascular Access, Point/Counter Point Presentation, 9/11/08.


