The Impact of Catheter Occlusion in Central Line Associated Bloodstream Infections

DARCY DOELLMAN MSN, RN, CRNI, VA-BC
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LOUISVILLE, KENTUCKY
Cincinnati Children’s Hospital

- 642 beds
- Rated #3 nationally
- Vascular Access Team (24/7)
  - 37 FTEs
- Services provided:
  - IV access
  - Midline and PICC insertions
  - CVC monitoring and complication management
- Education and research
Learning Objectives

- Describe types of catheter occlusion
- Review how to identify, prevent, and manage catheter dysfunction
- Discuss current guidelines and practices for reducing CLABSI rates
Central Venous Catheters

- Drastic increase in central venous catheters (CVCs) over past 30 years due to:
  - Increase use in TPN
  - Use of chemotherapy
  - Critically ill patients
  - Antibiotic therapy
  - Chronic conditions

Reference:
"Central" is defined as Catheter Tip in the Superior Vena Cava, Inferior Vena Cava or the Brachiocephalic veins.
Version: March 24, 2010
Catheter Occlusion

• Up to 25% of CVCs become occluded
• Three types of catheter occlusion
  ○ Mechanical
  ○ Nonthrombotic
  ○ Thrombotic

(Baskin 2009)
Mechanical Occlusion

- **External**
  - Clamped/kinked tubing
  - Position of patient
  - Tight suture around catheter
  - Port needle dislodgement

- **Internal**
  - Catheter tip malposition
  - Pinch-Off Syndrome
    - Compression of catheter between 1st rib and clavicle
    - Symptom: Flushing stops/starts in a predictable manner
      - Occurs in 1% of patients

(Dougherty 2006; Gabriel, 2006)
Pinch-Off Syndrome
Nonthrombotic Occlusion

- Precipitate
  - Extreme pH, calcium phosphate crystals, or lipid deposits
  - Crystallization of TPN
  - Drug precipitation
    - Diazepam, aminoglycosides, phenytoin
Thrombotic Occlusion

- Most common type of catheter occlusion
- Four types:
  - Intraluminal
  - Fibrin sheath
  - Fibrin tail
  - Mural thrombus

(Stephens 1999)
**Fibrin Formation**

- **CVCs are considered a foreign body in situ**
  - After placement, CVCs become covered with plasma proteins and fibrin
  - Within 24 hours, platelets and WBCs adhere to protein and allows for colonization of bacteria
Intraluminal Occlusion

- Occurs when blood refluxes inside CVC lumen
- Causes of reflux:
  - Patient coughing, emesis
  - Inadequate amount of flush after blood draws
- Leads to sluggish lumen or total occlusion
Fibrin Sheath

- Fibrin adheres to catheter surface
- May completely cover the opening of the catheter tip, like a sock
- Causes: injury to tunica intima
- A complete fibrin sheath may lead to infiltration or extravasation

(Gabriel 2006)
Fibrin Tail

- Tail extends from CVC tip
- Upon aspiration, fibrin tail blocks catheter lumen
- Results in an ability to infuse fluids but an inability to withdraw blood
- Leads to partial occlusion
Mural Thrombus

- Forms where the catheter touches the vein
- Can occur anywhere along the catheter path
  - Common with catheter tip malposition
- May lead to catheter thrombosis
Identification of Catheter Occlusion

- Routinely assess catheter for patency with flushing of CVC
- Patency: ability to flush and aspirate blood without resistance
- Sluggish lumen
- May be first symptom of a catheter occlusion
- May lead to a partial (withdraw) or complete occlusion
- Assess CVC further if catheter is sluggish
Rule Out Mechanical Factors

- Begin at infusion pump or catheter hub
- Assess for closed clamps, kinked tubing or catheter
- Is patient laying on the catheter?
- Has PICC migrated out?
- Change in port needle location?
- Is needleless connector clotted?
- Review MAR profile, is there a concern for precipitation?
- Has mechanical factors been resolved or ruled out?
Management of Occlusion

- Preferred approach is catheter salvage
- Manage as thrombotic occlusion if unable to determine type of occlusion
- Do not leave an occluded lumen untreated because another lumen is functional
Symptoms

- Resistance when flushing
- Sluggish flow
- Inability to infuse fluids
- Frequent occlusion alarm on infusion pump
Treatment for Thrombotic Occlusion

- **Alteplase (thrombolytic)**
  - 2mg/2mL sterile water
  - Can instill alteplase up to 2 doses
    - Adults: 2 mg/2mL
    - Pediatrics: 110% of the catheter priming volume
  - Dosing: Allow 1\textsuperscript{st} dose to dwell for up to 2 hours
    - If occlusion persists, instill 2\textsuperscript{nd} dose
  - Efficacy: Adults: 88% patency after 2 doses
    - 75% patency after 1 dose
    - Pediatrics: 83% patency after 2 doses

Treat all types of thrombotic occlusions
Thrombolytic Therapy

- **Urokinase**
  - 15,000 iu/1.5mL normal saline
  - 2nd dose 20,000 iu/2mL normal saline
- **Overall efficacy:** 70%
- **Reteplase:**
  - 0.4 U
- **Efficacy:** Up to 74% after 40 min
  - **Overall:** 90%
- **Tenectaplastase**
  - Small sample studies

(Baskin et al, 2012)
Treatment for Precipitation

- 1% HCL acid: Precipitation of medications with a low pH and calcium phosphate crystals
- NaHCO₃ can be treated with high pH infusate precipitations
- 70% ethanol for lipid residue

- Resolve chemical precipitate by instillation of clearing agent(s) recognized to dissolve precipitate
- All clearing agents dwell for 1 hour using catheter priming volume
Administration of Thrombolytic

- Thrombolytic therapy:
  - Instill alteplase by a 10mL syringe or stopcock method
  - Never flush catheter against resistance
- Allow adequate dwell time
Persistent Occlusion

- If clearing agent does not resolve catheter occlusion, consider chest x-ray or contrast study to assess catheter tip malposition
Persistent Partial (Withdraw) Occlusion

- If CVC remains dysfunctional (unable to obtain blood return)
- Do not continue to use CVC
  - In rare cases, consider transfemoral approach to pull off fibrin
Risks for Catheter Occlusion

- Catheter tip malposition
- Number of CVC lumens
- Large catheter to vessel ratio
- PICCs are prone to occlusion by a factor of >2 in comparison with other CVADs

- Ports have less catheter occlusion as compared to Broviac and Hickman catheters

(Moureau & Chopra, 2016)
Prevention

- Proper flushing technique
  - Volume of flush
  - Type of flush
    - Normal saline vs heparinized saline
  - Frequency of flush
  - Routine flushing and after blood draw
  - Push-pause flushing
  - Use 10mL syringe for flushing
  - Flush unused lumens per protocol

(Goosens 2014)
Prevention

- Ensure optimal CVC tip placement
- Minimizing catheter occlusions requires the tip placement for CVADs to be in the lower one-third of the superior vena cava near the junction of the right atrium
Prevention

- Review institutional data on CVC complications
- Use of valved PICCs
- Needleless connector
- Education of the nursing staff
  - Occlusion rate decreased in a 6-month period from 29% down to 8.5%
- Dedicated PICC team
  - Occlusion rate decreased from 32 to 15 occlusions

(Bartock 2010; Ngo, 2005)
Patient Family Experience

- Delays in therapy
  - At risk for suboptimal therapy
- Delays in procedures
- Delays in discharge
- Increased cost
Complications

- 14 - 36% complication rate within 2 years of CVC placement
- Increase cost
- Increase LOS
In animal studies, fibrin sheath formation around CVCs promoted:
- Colonization
- Infection
- Persistent bacteremia

(Mehall et al, 2004)
PICCs

- Retrospective study of hospital ortho patients
- 180 PICCs in 136 patients
  - Mean dwell: 21 days
- 36/180 (20%) removed due to complications
  - CLABSI: 8/180 (14%)
  - Occlusion: 11/180 (8%)

Two risk factors for CLABSI:
> 70 years of age
Two lumens or greater

(Valbouquet Schneider et al 2015)
Prospective study on 291 PICCs in oncology patients

Total # of PICC complications 70 (24.7%)

44 (15.1%) removed due to complications
- CLABSI: 12 (4.1%)
- Occlusion 7 (2.4%)

15% failure rate in patients receiving chemotherapy

(Bertoglio, 2016)
PICCs in Oncology Patients

- Prospective, multicenter, cohort study
- N= 477 patients
- 81 (17%) experienced complications
- 36 (7.5%) removed due to complications
  - 3.4% due to occlusions
  - 6 (1.7%) due to CLABSI

Patients with a BMI > 25 were more likely to have a PICC complication

(Kang et al, 2017)
CLABSI Prevention

- Two phases:
  - Insertion
    - Insertion checklist
    - Use of ultrasound
    - Credentialing of clinician
    - Standardized CVC insertion kits
    - Maximal sterile barrier/chlorhexidine skin antisepsis
  - Maintenance
    - Dressing changes
    - Needleless connector antisepsis
    - Tubing changes
    - Chlorhexidine bathing
Avoid the Femoral Vein

- Increases infection risk and deep venous thrombosis in adults
- Emergent situations only

(Lorente, Henry, Martin, et al, 2005)
Hand Hygiene

- Using alcohol-based waterless product or antiseptic soap and water
- Compliance measurements can be obtained by actual observation

Curlej & Katrancha 2016
CVC Insertion

- Insertion Checklist
- Credentialing of clinician
- Standardized CVC insertion kits
- Maximal sterile barrier
- Chlorhexidine skin antisepsis
Device Selection

- CVADs carry significant risk to patients
- Apply evidence-based guidelines for selection
- Avoid overuse of PICCs

- Vascular Access Teams can assist with difficult IV access, failed attempts, or specific patient conditions:
  - Obesity
  - Diabetes

(Moureau & Chopra, 2016)
Red/Yellow/Green List

**Peripheral Venous Infusion Risk**

This is an estimate of risk for phlebitis or local tissue injury due to extravasation. Risk derived from available evidence, CCHMC data and CCHMC expert opinion, subject to review and change as further evidence becomes available.

This does not apply in situations of emergency medical treatment. If a medication is not on this list, please refer to the CCHMC formulary or contact pharmacy (6-4291) for information.

<table>
<thead>
<tr>
<th><strong>Red</strong></th>
<th><strong>Yellow</strong></th>
<th><strong>Green</strong></th>
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</thead>
<tbody>
<tr>
<td>Higher Risk</td>
<td>Intermediate Risk</td>
<td>Lower Risk</td>
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**Red**
- Acyclovir
- Caffeine Citrate
- Calcium (all salt forms)
- Dextrose > 12.5%
- Doxycycline
- Mannitol 20% & 25%
- Promethazine
- Potassium > 60 mEq/L
- Sodium bicarbonate
- Sodium chloride ≥ 3%
- TPN > 950 mOsM/L
- Vancomycin
- Vasopressors such as Dopamine
- Chemotherapy Drugs

**Yellow**
- Acetazolamide
- Allopurinol
- Amikacin
- Amphotericin B (conventional)
- Arginine
- Ciprofloxacin
- Dextrose 10% to ≤12.5%
- Erythromycin
- Ganciclovir
- Lorazepam
- Midazolam
- Morphine
- Ondansetron
- Nafcinil
- Non-Ionic Radiology Contrast
- Phenobarbital
- Phenytion
- Potassium ≤ 60 mEq/L
- TPN ≤ 950 mOsM/L

**Green**
- Aminophylline
- Amphotericin B Liposomal
- Ampicillin
- Ampicillin/Subbactam
- Cefazolin
- Cefotaxime
- Ceftriaxone
- Cefuroxime
- Clindamycin
- DSLR
- Dextrose < 10%
- Diazepam
- Fenotyl
- Fosphenytoin
- Furosemide
- Gentamicin
- Heparin
- Imipenem
- IVIG
- Lactated Ringers
- Lipids
- Magnesium sulfate (bolus)
- Meropenem
- Methylprednisolone
- Normal saline
- Pentamidine
- Piperacillin
- Piperacillin/tazobactam
- Ticarcillin
- Ticarcillin/clavulanate
- Tobramycin

**NOTE:**
- No peripheral intravenous infusion is “safe”.
- Gross extravasation, even of normal saline, may result in serious harm including compartment syndrome, causing ischemia and loss of tissue or permanent loss of limb function.

*Peripheral Venous Access is defined as any Venous Access Device whose tip lies outside the Right Atrium, Superior / Inferior Vena Cava, or the Brachiocephalic Veins*
CLABSI Reduction

- Reduce the # of CVCs inserted
- Alternative devices include:
  - Ultrasound guided IV insertion
  - Midline catheter insertion
- Assess daily need for CVC
- Promptly remove catheters that are not being used
## MAGIC Guidelines/INS

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Proposed Duration of Infusion</th>
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<tbody>
<tr>
<td></td>
<td>≤5 d</td>
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<tr>
<td>Peripheral IV catheter</td>
<td>No preference between peripheral IV and US-guided peripheral IV catheters for use ≤5 d</td>
</tr>
<tr>
<td>US-guided peripheral IV catheter</td>
<td>US-guided peripheral IV catheter preferred to peripheral IV catheter if proposed duration is 6–14 d</td>
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<tr>
<td>Nontunneled/acute central venous</td>
<td>Central venous catheter</td>
</tr>
<tr>
<td>catheter</td>
<td>catheter preferred in critically ill patients or if hemodynamic monitoring is needed for 6–14 d</td>
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<tr>
<td>Midline catheter</td>
<td>Midline catheter preferred to PICC if proposed duration is ≤14 d</td>
</tr>
<tr>
<td>PICC</td>
<td></td>
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<tr>
<td>Tunneled catheter</td>
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<tr>
<td>Port</td>
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- PICC preferred to midline catheter if proposed duration of infusion is ≥15 d
- PICC preferred to tunneled catheter and ports for infusion 15–30 d
Antibiotic Coated Catheters

- **240 community hospital in California**
  - Control group: 257 patients, 8 CLABSIs with an infection rate of 4.18/1,000 line
  - Study group: 260 patients, 1 CLABSI with an infection rate of 0.47/1,000 line days.

(Rutkoff, 2014)
CLABSI

- The estimated mortality rate associated with CLABSI is 23.8%, with an average increase LOS up to 21 days and an estimated cost of $29,156 per patient
Single Lumen vs Multi-lumen CVCs

- In the absence of indications for a multilumen PICC, use a single-lumen PICC of the smallest gauge
- Insert the smallest catheter french size with the lowest number of lumens
Criteria for a Multi-lumen CVC

- Continuous vesicant or irritant chemotherapy with additional lumen needs
- Need for vasopressors
- Milrinone
- Need for simultaneous administration of multiple incompatible medications
- TPN plus additional lumen needs
Senior Leadership

- Senior leadership can help reduce CLABSI rates by:
  - Driving the implementation of best practices and technologies
  - Promoting compliance with nursing staff
  - Support of staff for continuing education (conferences, certification)
  - Invest in EMRs that align with data collection and reporting
  - CLABSI task force member
Catheter occlusion is a common complication of CVCs

- Assess CVC patency with routine flushing, medication administration, and blood sampling
- Prevention and prompt treatment of occlusions is vital for CVCs
- Choose the most appropriate VAD based on the patient’s type and length of therapy
- Avoid unnecessary CVCs
- Follow current CVC bundles for reducing CLABSI
Thank You

- Darcy.doellman@fuse.net
Thank You