Consequences of Central Venous Catheterization

Identification, Discussion and Methods for Reduction of Common Post-insertion Complications

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Disclosure

Clinical consultant
- Interrad Medical
- Magnolia Medical Technologies
- Teleflex

Learning Objectives

- Identify four complications associated with presence of a central venous catheter (CVC) or peripherally inserted central catheter (PICC)
- Discuss clinical significance of these complications and their relationship
- Describe methods associated with reduction of these common complications
- Review opportunities for vascular access/infusion nurse specialists to participate in healthcare reform practices
PICC and CVC Complications

- Infection
- Thrombosis
  - SVC Syndrome
  - Pulmonary embolus
  - Post-thrombotic syndrome
  - Catheter dysfunction
- Air embolus
- Catheter tip migration/malposition

Central Venous Catheter Volume

During the past decade, there has been a steady increase in the number of PICC insertions and a decrease in the median PICC dwell times (Gibson 2013).

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Sum of 2011 Units</th>
<th>Sum of 2013 Units</th>
<th>Net Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute CVC</td>
<td>2,040,631</td>
<td>1,817,632</td>
<td>223,999</td>
</tr>
<tr>
<td>Chronic CVC</td>
<td>133,749</td>
<td>145,204</td>
<td>11,455</td>
</tr>
<tr>
<td>PICC</td>
<td>2,591,167</td>
<td>2,223,624</td>
<td>367,543</td>
</tr>
</tbody>
</table>

Stats provided by Teleflex

Consequences of Central Venous Catheterization

INFECTION
Incidence of CVC-Associated Infection

- 10 medical centers with mean bed size of 800 (Son 2012)
- Rates 0.2 to 4.2/1000 with median 2.5/catheter days
  - CDC 2009 data from NHSN was 1.4/1000 catheter days
- Only 2 hospitals were below pooled CLABSI rates for inpatient wards....why?
  - Differences in average central line utilization
  - Hospital affects clinical risk factors

Incidence of PICC-Associated Infection

<table>
<thead>
<tr>
<th>INFECTION</th>
<th>Patients without Cancer</th>
<th>Patients with Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence</td>
<td>1.0 to 2.1/1000 catheter days</td>
<td>1.8 to 7.7/1000 catheter days</td>
</tr>
<tr>
<td>Mortality</td>
<td>Estimated 12-25%</td>
<td>Estimated 31-36%</td>
</tr>
</tbody>
</table>

- PICC-associated CLABSI: 2.69/1000 PICC-days (Baxi 2013)
- PICC-associated CLABSI: 3.13/1000 catheter days (Ajenjo 2011)
  - ICU: 4.79/1000 catheter days
  - Acute care: 2.79/1000 catheter days

PICC-Associated Infections

PICCs are both short- and long-term devices
- Both intra- and extra-luminal routes become relevant in CLABSI with PICCs (Chopra 2013)

Risk of infection increases the longer PICC dwells
- 23% with infection early onset < 7 days (78/255)
- 77% had PICC infection after dwell >7 d (187/255)
- Important to know when looking at choice of empirical antimicrobials in patients

Staphylococcus aureus
**Independent Risk Factors for PICC BSI**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestive heart failure</td>
<td>2.0</td>
</tr>
<tr>
<td>Clostridium difficile</td>
<td>2.25</td>
</tr>
<tr>
<td>Intra-abdominal perforation</td>
<td>5.66</td>
</tr>
<tr>
<td>Recent chemotherapy</td>
<td>3.36</td>
</tr>
<tr>
<td>Presence of tracheostomy</td>
<td>5.88</td>
</tr>
<tr>
<td>Double lumen catheter</td>
<td>1.89</td>
</tr>
<tr>
<td>Triple lumen catheter</td>
<td>2.87</td>
</tr>
</tbody>
</table>

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**Does a connection exist?**

Catheter-related infection and catheter-related thrombosis

**Triad of Complications**

- Infection
- Thrombosis
- Malposition

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**Consequences of Central Venous Catherization**

**THROMBOSIS**
Thrombotic Potential

Defined as:
- Interaction of multiple inherited and acquired risk factors (Rosendaal 1999)
  - Risk of DVT increases with the number of risk factors present

Hospitalized patients have:
- 1.5 risk factors per patient
- 26% of these patients have 3 or more risk factors present (Anderson 1991)

Thrombotic Threshold

- Threshold is a specific level of an indicator that should prompt a review (Lewis 2003)
- Symptomatic subclavian and jugular-associated thrombosis
  - Threshold is 8%
- Symptomatic PICC-associated thrombosis
  - Threshold is 6%

CVC-Associated Thrombosis

- Percutaneously inserted CVC
  - Symptomatic rates: 2%-26% (Trerotola 2010)
  - Asymptomatic CRT: 33% but reported as high as 66% (VanRooden 2005)
  - Range varies due to diagnostic modality (US, Doppler, Venogram)

UEDVT account for 5-10% of all adult DVT (Avila 2014)
30-50% of cases of pediatric DVT involves UE (Avila 2014)
**PICC-Associated Thrombosis**

<table>
<thead>
<tr>
<th>THROMBOSIS</th>
<th>Patients without Cancer</th>
<th>Patients with Cancer</th>
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<tbody>
<tr>
<td>Incidence</td>
<td>2.0 to 5.5%</td>
<td>3.4 to 7.8%</td>
</tr>
<tr>
<td>Mortality</td>
<td>Estimated 1-2%</td>
<td>Estimated 2-4%</td>
</tr>
</tbody>
</table>

PICC is associated with higher risk of DVT than CVCs, especially in critically ill or patient with a malignancy (Chopra 2012)

**Thrombosis in the Oncology Patient**

Venous thromboembolism is second leading cause of death in cancer patients, after metastasis (Farge-Bancel 2014)

- Increased risk for cancer patients is due to:
  - Some cancers secrete substances that make blood more prone to clotting
  - Chemotherapy can increase tendency to clot
  - However, decreased platelets also increase risk of bleeding
- Less mobile; presence of CVC
- In 50% of deceased patients with cancer, undiagnosed DVT or PE was found at autopsy (Khorana 2007)

**Risk Factors for Catheter-Related Thrombosis**

Virchow’s triad and previously recognized risk factors
- Infection (Rogers, 2012)
- Insertions > than 25 minutes and >1 attempt (Farge-Bancel 2013)
- Blood transfusions (Rogers, 2012)
- High platelet count at time of insertion
- Subclavian > Jugular; Left > Right (Farge-Bancel 2013)
- PICCs in patients receiving chemotherapy (Farge-Bancel 2013)
- Trimming PICC tip (Steele 2014)
- Catheter to vessel ratio >45% (Sharp, 2015)

Source: Oley.com
An obvious connection: Catheter-related thrombosis and catheter-related infection

So….Place a PICC or CVC?

Most importantly is to be aware that PICC insertion dramatically increased but clinical study data lagged behind

- Catheter-related *infection* rate comparison: (Yamp 2014)
  - Out-patient rates lower than in-patient rates
  - Inpatient rates are similar between PICC and CVC
- Catheter-related *thrombosis* rates are higher with PICC than CVC (Yamp 2014)
- Catheter tip *malposition* rates are generally higher with PICC than CVC (Yamp 2014)

Consequences of Central Venous Catheterization

**SUPERIOR VENA CAVA SYNDROME**
Superior Vena Cava Syndrome

- Occurrence is 1 in 15,000
- Compression or occlusion of the SVC
- Symptoms generally occur gradually
  - Difficulty in diagnosis due to symptomology

Extrinsic compression:
- Tumor—85% related to cancer (lung cancer most common) (Pearl 1999)
  - 85% related to cancer (lung cancer most common)

Intrinsic occlusion:
- Presence of CVC’s (7%) followed by pacemakers
- Generally acute in nature

Symptoms:
- Fullness in head, dyspnea, cough, facial/neck edema, presence of collateral circulation, cyanosis

Source: Biomedsource.com

Source: Nature Clinical Practice
Management of SVC Syndrome

Supportive
- Steroids
- Anticoagulation

Definitive treatments
- Thrombectomy
- Endovascular intervention with stenting

Consequences of Central Venous Catheterization

PULMONARY EMBOLUS

- In patient with CVC, no evidence of thrombosis may be present and PE may be first symptom noted
- Risk factors include
  - Similar as risk factors for DVT—hospitalization, surgery, trauma, malignancy, paralysis, pacemaker
  - Presence of CVC and resulting CR thrombosis
Incidence of Pulmonary Embolus

- Generally asymptomatic and subclinical
- Occurs in 15% of patients with CR UEDVT
- Femoral: 8.5% to 26% (Merrer 2001)
- Cancer patients: 15% to 18%, Autopsy proven up to 50%

There have been reports of pulmonary embolus related to CVC exchange!

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Pulmonary Embolus: A Lethal Complication

Hingorani 1997
- PE documented with ventilation/perfusion scan
  - 33/430 patients (8%) of LEDVT
  - 9/52 patients (17%) of UEDVT
- 48% with UEDVT died within 6 months of DVT
- 13% with LEDVT died within 6 months of DVT

Conclusion:
- UEDVT associated with higher morbidity and mortality than LEDVT

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Pulmonary Embolus in Children

- ~25% of PE in children CVC is present
- Autopsy study from PICU (Derish 1995)
  - 5 children and all developed respiratory failure, vent dependence and had a CVC in place
  - Diagnosis of PE missed in assess despite presence of clinical symptoms
    - Symptoms similar with severe lung disease
    - Were confused with respiratory failure

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Visualizing Pulmonary Embolus

Consequences of Central Venous Catheterization
POST-THROMBOTIC SYNDROME

Post Thrombotic Syndrome

Symptoms vary from patient to patient

Patient complaints
- Tenderness of extremity
- Numbness
- "Aching" pain
- Heaviness
- Weakness

Clinical symptoms
- Venous hypertension
  - Edema
  - Discoloration
- Presence of venous collaterals
- Erythema
- Fatigue with exertion
Post Thrombotic Syndrome

- Consequence of DVT of upper or lower extremity
- Can occur months after DVT occurrence
- Debilitating condition especially if dominate arm is involved
- Why does it occur?
  - Damage to valves and impaired venous return
  - Thrombus is not resolved after treatment
- Occurrence as high as 35% (Polen 2015)
- Identification of presence of UEDVT is critical to provide treatment options

Improving Post Thrombotic Syndrome Outcomes

Methods for bettering PTS outcomes include:
- Anticoagulation treatment for DVT prevent new clots from forming
- Body eventually dissolves clot, but damage to vein occurs in meantime
- Removal or lysis of thrombus gives better outcomes than anticoagulation
- Leaving CVC in place also increases risk of PTS as compared to removal of CVC

Consequences of Central Venous Catheterization

AIR EMBOLUS
CVC Associated Air Embolus

- Occurs when venous pressure is less than the pressure and conduit is created into the venous system
- Rate 1 in 47 to 1 in 3000 which is low (Fiel 2012)
  - However, mortality from 23 to 50% (Fiel 2012)
- Sequelae dependent on volume, rate, route of air passage
  - Risk increased with injection closer to heart
  - Lethal dose is 3-5 ml/kg
  - 300-500 ml of gas introduced at a rate of 100 ml/sec is a fatal dose for humans (Gordy 2013)
- 25% of population have patent foramen ovale (PFO)

Air Embolism

Most common causes
- Fowler’s position surgery and ENT procedures
- Central venous catheterization, maintenance, removal

Symptoms:
- Sucking air sound, dyspnea, tachycardia, chest pain, hypotension

Treatment:
- Stopping the air entry
- Aspiration of air from right ventricle if possible
- Position in Trendelenburg, left lateral decubitus

Air Embolus

- Preventable hospital acquired condition
- “Never Event”
  - Labeled a serious reportable event with nonpayment for harm by the Centers for Medicare and Medicaid Services (CMS)
  - Along with CLABSI
Consequences of Central Venous Catheterization

CATHETER TIP MALPOSITION

Appropriate Catheter Tip Location

Upper extremity
- Lower 1/3 of superior vena cava-right atrial junction

Lower extremity
- Inferior vena cava at level of diaphragm (Abbas 2013)
- When tip is distal SVC, risk of displacement is reduced by 89% (Lozano 2012)

Characteristics of Appropriate Tip

- Parallel with vessel wall (Hadaway 1998)
- Avoids abutting vessel wall
- Near cavo-atrial junction
  - Large vein size, minimizing vessel wall contact
  - High turbulent blood flow for maximum hemodilution
Characteristics of Inappropriate Tip

- Dysfunction of catheter when flushing or aspiration
- Change in external length of CVC or PICC
- Poor flow rates
- Absence of characteristic waveform
- “Thoracic Pain Syndrome”
  - Unusual tachycardia during infusion or flushing through central line

Ramifications of Inappropriate Tip

- Thrombus
  - Thrombosis 16X higher when position high in SVC
- Infection
- Migration
- Intimal Injury / Impingement
- Perforation / Extravasation

Appropriate Catheter Tip Location

SVC perforation, dye study
An obvious connection: Catheter tip malposition and catheter-related thrombosis

Triad of Complications

Infection

Thrombosis

Malposition

Proximal SVC Tip

Right Atrial Tip in a Neonate
Azygous Vein Catheter Tip

PICC Advancement into Collateral Circulation

Is there a connection?
Catheter tip malposition and catheter-related infection

Triad of Complications:
- Infection
- Thrombosis
- Malposition

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Consequences of Central Venous Catheterization

HEALTHCARE REFORM AND THE INFUSION SPECIALIST

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Financially Speaking

- Affordable Care Act (ACA)
  - It's the law! Do you understand it?
- Motivation for ACA
  - Aging population
  - Growing burden of chronic disease
  - Gaps in quality health care
- Solution
  - Incentivize for high quality hospitals and care

Pay for Performance

- Value Based Purchasing (VBP)
- Hospital Readmissions Reduction Program (HRRP)
- Hospital Acquired Condition (HAC)
- Goals:
  - Improve patient experience
  - Improve health
  - Reduce per capita cost of healthcare
Your Role in Healthcare Reform

Nurse’s role in reforming healthcare
- Develop needed innovations
- Enhance technology
- Generate evidence
- Redefine relationships
- Expand scope of practice
- A seat at the table

Be a Part of the Solution!

• As an educator
• As a certified specialist
• As a researcher
• As a financial participant
• Expand clinical practice

Become a valuable team member in these challenging economic times!

Questions?
References