Preventing Central Venous Catheter Complications- An evidence based approach

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Learning Objectives

- Discuss about various types of Central Venous Catheters (CVCs) and their indications
- Review complications of CV catheterization
- Discuss factors affecting complication rates
- Discuss interventions for preventing CVC related complications
**Background**

- > 5 million CVC’s inserted every year
- 15 million CVC days/year in ICU
- Useful for invasive monitoring and therapeutic purposes
- Associated with adverse event rate that are hazardous to patients and expensive to treat (2-26%)
- Target area for quality improvement
Historical Perspective

- Unpublished reports of central venous access in early 1900’s

- First published work: Werner Forssmann 1929; Nobel Prize in Medicine for Cardiac Catheterization in 1956
Types of CVC’s

CVC: By definition tip resides in the central circulation

Non-Tunneled
- Single or multi-lumen, Hohn (<6 weeks), cordis etc
- PICC (long term)
- PA catheters

Tunneled (long term)
- Groshong, Hickman catheter etc
- Implanted port
- Permacath
Types of CVC's

Hohn catheter

PICC
Types of CVC’s

Port

Groshong
Indications for a CVC

- **Therapeutic indications**-
  - Administration of chemotherapy, TPN, blood products, IV medications and fluids
  - Hemodialysis and plasmapheresis

- **Diagnostic indications**
  - Establishing or confirming diagnosis
  - Establish prognosis
  - Monitor response to treatment
  - Repeated blood sampling
Clinical Case 1

- 61 y/o M with hx of enterocutaneous fistula needing 6 months of TPN

- A single lumen non tunneled right IJ silicone Hohn catheter placed by IR

- Presented six wks later to PCP with subjective fevers for a week.

- Two sets of blood cultures drawn in clinic grow gram negative bacilli.
Clinical Case 1

- On admission pt febrile to 38.5 with a WBC count of 16.5, BP 99/60, creatinine of 2 (baseline 1)
- Chlorhexidine sponge absent at the catheter site
- Pt diagnosed with sepsis due to Central Line Associated Blood Stream Infection (CLABSI) and started on zosyn.
- CVC removed and tip cultured, cultures from blood and cath tip grow Klebsiella Oxytoca
Complications of CVC

- Mechanical
- Thrombotic
- Occlusion

Early (insertion)  |  Delayed (days)

Infection
Complications of CVC

- **Mechanical complications**

  - Complications occurring during the insertion of a CVC (< 0.1-19%)

  

<table>
<thead>
<tr>
<th>Complication</th>
<th>Internal Jugular</th>
<th>Subclavian percent</th>
<th>Femoral percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial puncture</td>
<td>6.3–9.4</td>
<td>3.1–4.9</td>
<td>9.0–15.0</td>
</tr>
<tr>
<td>Hematoma</td>
<td>&lt;0.1–2.2</td>
<td>1.2–2.1</td>
<td>3.8–4.4</td>
</tr>
<tr>
<td>Hemothorax</td>
<td>NA</td>
<td>0.4–0.6</td>
<td>NA</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>&lt;0.1–0.2</td>
<td>1.5–3.1</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>6.3–11.8</td>
<td>6.2–10.7</td>
<td>12.8–19.4</td>
</tr>
</tbody>
</table>

McGee D et al NEJM 2003; 348;12: 1123-33
Complications of CVC

- **Mechanical complications**
  - Other: arrythmias, malposition, air embolism & tamponade rare but possible
  - Cardiac tamponade (most serious)
  - PICC : 0.5-1% (hematoma and arterial injury)
Complications of CVC

- **Thrombotic**
  - CVC - thrombogenic and high risk for thrombosis
  - About 50% of venous thrombosis in the ICU are catheter related
  - Femoral (21.5%) > PICC > Internal jugular > Subclavian (1.5%)
  - Risk of embolization
  - Treated as a DVT as clinical significance unknown
Complications of CVC

- **Infectious**
  - Catheter colonization
  - Exit site infection
  - Central Line Associated Blood Stream Infection (CLABSI)
Complications of CVC

- **Infectious**
  - ~ 250,000 CLABSI occur each year in the US (~80,000 in the ICU)
  - Incidence is 3.8-5.3 /1000 catheter days in the ICU
  - Attributable mortality from CLABSI- 12%-25%
  - Attributable cost/infection- $6,000- $40,000 (higher in the ICU)
  - Increased length of stay
The CMS exercised its authority under section 5001(c) of the DRA by announcing that Medicare will no longer pay the extra cost of treating the following categories of conditions that occur while the patient is in the hospital:

- pressure ulcer stages III and IV;
- falls and trauma;
- surgical site infection after bariatric surgery for obesity, certain orthopedic procedures, and bypass surgery (mediastinitis);
- vascular-catheter associated infection;
- catheter-associated urinary tract infection;
- administration of incompatible blood;
- air embolism; and
- foreign object unintentionally retained after surgery.
Complications of CVC

- Mechanisms of infection

Maki DG, Hospital Infections, Little Brown & Co, 1992
Complications of CVC

- **Catheter Occlusion**
  - Usually considered as a minor complication
  - Fibrin sheath or thrombus formation at the tip of the catheter
  - PICC (0.4) > CVC (0.08) > Port, Tunneled CVC (0.04) (event rate/1000 catheter days)

Moureau N et al JVIR 2002;13:1009-16
Strategies for Preventing Central Venous Catheter Complications- What’s the Evidence?
Clinical Case 2

- 59 y/o F in the MICU with COPD, multi-focal pneumonia causing septic shock and resp failure on mechanical ventilation needs a CVC for pressors and antibiotics.
- The intern asks what is the best CVC site for her and the maximum number of attempts he could try to insert the CVC.

a) Right subclavian with 4 passes
b) Left IJ with 2 passes
c) Right femoral with 5 passes
d) Right IJ with 3 passes
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d) **Right IJ with 3 passes**
Preventing Mechanical Complications

- **Patient factors**
  - Insertion at a site of scarring, surgery or skeletal deformity
  - Coagulopathy, obesity, volume depletion, uncooperative/delirious pt etc

- **Operator factors**
  - Failure to insert after three attempts increases risk by six times
    (Mansfield, NEJM 1994;331:1735-38)
  - Operators with ≥ 50 insertions have 50% less complications
    (Sznajder J I, Arch IM 1986;146:259-261)
Preventing Mechanical Complications

- **Avoid femoral catheterization**
  - Twice as high complications compared to Subclavian or IJ approach (Merrer J JAMA 2001;286:700-707)

- **No role for routine catheter site change**
  - 9% risk of mechanical complications (Cobb DK, NEJM 1992;327:1062-68)

- **Simulation based training**
  - Decreased risk of arterial punctures and higher success rate (Barsuk JH et al, Crit Care Med. 2009 Oct;37(10):2697-701)
Preventing Mechanical Complications

- **Use Ultrasound during insertion**
  - Associated with decreased risk for mechanical complications during IJ CVC placement
    (Randolph AG, Crit Care Med 1996;24:2053-58.)
Preventing Mechanical Complications

- **Use Ultrasound during insertion**
  - Increased successful cannulation in internal jugular approach by 10%
  - Reduced incidence of arterial puncture from 8.3% to 1.7%
  - Average access time reduced by a factor of 4
  - Ultrasound visualization of subclavian vein more difficult and has not been shown to reduce complications

Preventing Mechanical Complications

- **Pneumothorax**
  - Consider IJ placement to decrease the risk
  - Insert on the ipsilateral side of a chest tube

- **Air embolism**
  - Occlude catheter hub at all times and patient placed in Trendelenberg position

- **Cardiac tamponade and arrhythmia**
  - Consider placing CVC outside of the pericardial silhouette
Clinical Case 3

- 35 y/o M with dilated CM in the ICU with chf needing dobutamine, the nurse requests a central line. What is the best recommended practice to decrease the chance of a line infection.

a) Place rt subclavian with chlorhexidine prep and a small drape and sterile glove
b) Place lt IJ with povidone prep and maximal barrier precautions
c) Place rt subclavian with chlorhexidine prep and maximal barrier precautions
d) Place right femoral with chlorhexidine prep and maximal barrier precautions
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Preventing CLABSI

- **Independent risk factors**
  - Prolonged hospitalization before catheterization
  - Prolonged duration of catheterization
  - Heavy microbial colonization at the insertion site
  - Heavy microbial colonization of the catheter hub
  - Internal jugular and femoral catheterization
  - Neutropenia
  - Total parenteral nutrition
  - Substandard care of the catheter (excess manipulation)

Preventing CLABSI

- **Operator factors**

  - **Hand hygiene:** No RCT's comparing hand washing to no hand washing but good practice!
  - Achieved either by alcohol based products or antibacterial soap with adequate rinsing
  - RCT comparing the two found similar rate of surgical site infection 2.44% vs. 2.48% (alcohol vs. soap) 95% CI – 0.88, 0.96 p <0.001
Preventing CLABSI

- **Effect of catheter material**
  - Evidence lacking
  - Anecdotal and lab reports suggest that Silicone catheters associated with a higher risk compared to Polyurethane

Preventing CLABSI

- **Site of placement**
  - Subclavian site lowest risk for CLABSI with highest risk for femoral site (4.5% vs 19.8)
    (Merrer J, JAMA. 2001 Aug 8;286(6):700-7)
  - Consider tunneled catheter or PICC for long term access
  - Implanted Port has the lowest risk
    (O’Grady, MMWR Aug 9, 2002, Vol 51)
Preventing CLABSI

• Role of Antibiotic Impregnated Catheters -

  • RCT's:


    * 7.6 infections/1000 cath days (5 %) ---- 1.6/1000 cath days (1%), RR 0.21 95% CI 0.03, 0.95 p = 0.03


    * 7.3 infections/1000 cath days (5%) ---- 0/1000 cath days (0%), p < 0.01
Meta-analysis of CLABSI Rates with Chlorhexidine+ Silvadene coated CVC

Summary

George Trazzera
Ramsay
Pemberton
Collin
Heard
Bach
Hannan
Maki
Tennenberg

OR 0.56, 95% CI (0.37-0.84)

Preventing CLABSI

Cost effectiveness of Antibiotic Catheters

- Cost effectiveness study of chlorhexidine + silvadene impregnated catheters
- Decrease in CLABSI by 2.2% and cost saving of $196 per catheter
- Consider when the institutional rate of the CLABSI is > 2.2%

Cost-Effectiveness of Antiseptic-Impregnated Central Venous Catheters for the Prevention of Catheter-Related Bloodstream Infection

David L. Veenstra; Sanjay Saint; Sean D. Sullivan

Preventing CLABSI

- **Effect of multi lumen catheters**
  - Lack of RCTs comparing number of lumens
  - Multiple observation studies show increased risk with more lumens: ~3.7% (single) vs. ~7% (triple)

Effect of multi lumen catheters

- CLABSI common in multi lumen CVC (OR, 2.15; 95% CI 1.00-4.66), catheter colonization was not (OR, 1.78; 95% CI, 0.92-3.47)

- Analysis of studies of higher quality showed no effect on CLABSI (OR 1.30; 95% CI 0.50-3.41)

- Evidence equivocal, IDSA recommends using CVC with minimum number of lumens as needed

Preventing CLABSI

- **Role of sterile barriers**
  - A RCT using maximal sterile barrier (sterile gloves, caps, gown, mask and full body large drape) vs. sterile gloves and small drape decreased rate of infection from 7% to 2% (p= 0.03)
  - Cost saving of $167 per catheter
  - Similar results and cost savings found on another clinical and cost effective analysis

Preventing CLABSI

- **Antibiotic ointments**
  - No affect on the rate of CLABSI
  - Promotes fungal colonization and drug resistant bacteria

Preventing CLABSI

- **Routine scheduled catheter changes**
  
  - Two RCTs evaluated a routine q7 day change in catheters
  - No reduction in rates of CLABSI

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Uldall PR et al, Changing subclavian haemodialysis cannulas to reduce infection. Lancet 1981;1:1373
**Routine guidewire catheter changes**

- Associated with a trend towards increased risk of CLABSI but fewer mechanical complications

Preventing CLABSI

- **Role of skin antisepsis**
  
  - A RCT compared 2% chlorhexidine gluconate vs. 10% povidone iodine or 70% ethyl alcohol.
  
  - CLABSI rate of 0.5% (chlorhexidine group) vs 2.3% and 2.6% (povidone iodine and ethyl alcohol respectively) OR 0.16 p = 0.04.
  
  - 2% Chlorhexidine superior to other antiseptic solutions.

Role of skin antisepsis

- A meta-analysis also demonstrated superiority of chlorhexidine over povidone iodine

Role of dressing material

- A meta-analysis of RCT’s of studies comparing polyurethane transparent dressing vs. gauze
- Trend towards increased infection with transparent dressing but statistically insignificant

Role of Chlorhexidine impregnated sponge (Biopatch ®)

- Multicenter RCT compared Biopatch ® vs. routine standard of care in 589 subjects
- 44% reduction in local infection (p < 0.0001)
- 60% reduction in CLABSI

<table>
<thead>
<tr>
<th>Intervention</th>
<th>No CLABSI rate (%)</th>
<th>CLABSI rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biopatch</td>
<td>288 (97.6)</td>
<td>7 (2.4)</td>
</tr>
<tr>
<td>Control</td>
<td>276 (93.9)</td>
<td>18 (6.1)</td>
</tr>
<tr>
<td>Total</td>
<td>564</td>
<td>25</td>
</tr>
</tbody>
</table>

(P = 0.026)

Maki DG et al. Toronto, Ontario: American Society for Microbiology, 2000
Preventing CLABSI

- **Role of systemic antibiotic prophylaxis**

  - Oral or parenteral antibiotics have no effect on the incidence of CRBSI among adults

Preventing CLABSI

- **Role of disinfection of catheter hubs**

  - Disinfecting catheter hubs with friction for 15 secs using either 70% alcohol or chlorhexidine/alcohol solution associated with decreased bacterial colonization

Preventing CLABSI

- Role of evidence based interventions

The NEW ENGLAND JOURNAL of MEDICINE

An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU

Peter Pronovost, M.D., Ph.D., Dale Needham, M.D., Ph.D., Sean Berenholtz, M.D., David Sinopoli, M.P.H., M.B.A., Haitao Chu, M.D., Ph.D., Sara Cosgrove, M.D., Bryan Sexton, Ph.D., Robert Hyzy, M.D., Robert Welsh, M.D., Gary Roth, M.D., Joseph Bander, M.D., John Kepros, M.D., and Christine Goeschel, R.N., M.P.A.

- Landmark cohort study in 106 ICU’s in Michigan
- Intervention using five evidence based procedures to reduce CLABSI
Preventing CLABSI

- Role of evidence based interventions

  - Procedures: hand washing, using full-barrier precautions during insertion of CVC, cleaning the skin with chlorhexidine, avoiding the femoral site if possible, and removing unnecessary catheters.

  - Median CLABSI rate decreased from 2.7/1000 cath days to 0/1000 cath days at 3 months ($p \leq 0.002$)

  - Mean CLABSI decreased from 7.7/1000 cath days to 1.4/1000 cath days at 16-18 months of follow up

  - 66% reduction of CLABSI at 18 month period
# Evidence Based Interventions at Denver Health

<table>
<thead>
<tr>
<th>DENVER HEALTH MEDICAL CENTER</th>
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<tbody>
<tr>
<td>ADULT BEDSIDE PROCEDURE CHECKLIST RECORD</td>
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</tbody>
</table>

- **Operating and assisting clinicians:** (Observers and other staff – Wear mask and gloves as indicated)
  - □ Hands and forearms washed for at least 20 seconds with alcohol foam.
  - □ Insertion site prep: Chlorhexidine swabstick. *(NOT Betadine unless allergic to chlorhexidine)*
  - □ If Betadine used, remove after 2 min using 70% isopropyl alcohol swabs
  - □ Required PPE worn. *(Gown, gloves, cap)*
  - **“TIME OUT” called** □ Yes □ No. By whom: □ RN □ Resident □ Observer □ Attending □ Other

| 1. □ Patient supine, Trendelenberg greater than or equal to 15° unless contraindicated. Consider rolled towel or 1 L IV bag between scapula with head turned away from insertion site, unless contraindicated. |
| 2. □ RN Prepare 3X sterile saline flush syringes if not in kit. Consider mask/drape over patient’s mouth and nose, if ETT/trach consider cap over patient’s hair |
| OBSERVER monitor for sterility breaks and call “STOP” |
| 3. □ Full body fenestrated drape; MAY NEED TO REGLOVE |
| 4. □ Estimate position of distal tip by surface-landmark guidance. Safe insertion (adults): L or R IJ/Subclav = 16 cm; PA cath = 45-50 cm; (Varies by insertion site and body position; See pkg insert.) |
| 5. □ Locate vessel with ultrasound guidance – NO MORE THAN 3 PASSES WITH FINDER NEEDLE; CONSIDER CXR IF VESSEL NOT LOCATED BY 3rd PASS |

| 6. □ Occlusive Central Line Dressing per P&P. |
| 7. □ Order portable chest XRay; Confirm position Position of catheter tip appropriate □ Yes □ No PTX □ Yes □ No. Other Complications |
| 8. □ Observer notes that guidewire passes easily and monitors for PVC/VT. DO NOT PERFORM INTRODUCER-TO-CATHETER EXCHANGE until venous access confirmed Arterial cannulation □ Yes □ No Describe corrective action |

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For detailed instructions, refer to the linked PDF document provided by Denver Health.
Clinical Case 1

- Patient discharged six days later on 10 days of oral levaquin after blood cultures cleared with a Groshong (tunneled) catheter.

- Key risk factors in this case: IJ placement, Hohn catheter, lack of catheter site care, TPN
Preventing Thrombotic Complications

- **Site of insertion**
  - Subclavian insertion lowest risk for thrombosis
    - (Merrer J JAMA 2001;286:700-707)
    - (Hamilton HC et al, Cochrane Datab Syst Review, 2007 Jul 18; (3))

- **Role of anticoagulants in prophylaxis**
  - Possible benefit in a systematic review for use of low dose warfarin and low dose LMWH in patients with solid tumors
    - (Klerk CP, Arch IM 2003 Sep 8;163(16):1913-21)
  - Consider heparin bonded catheter in high risk pts
Conclusions

• CVC complications are hazardous to patients and expensive to treat

• Practice evidence based guidelines to reduce complication rate

• Assess need for CVC daily and remove if not needed

• Make institutional commitment to eliminate complications

• Offer training courses in central line placement

• Follow complication rates and provide feedback
Questions are guaranteed in life; Answers aren’t.