Complications of central venous catheters: current perspectives

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Overview

- Outline the common complications associated with central venous catheters
- Identify the common strategies that can be employed to minimise the risk of these complications
- Present the evidence base surrounding these strategies and the implications for practice

“Lifeline” by Andy Scott
CVC complications

Catheter-related infection (CRI)

- Localised
  - Exit site infection
  - Tunnel infection
  - Port pocket infection
- Systemic
  - Infusate related
  - Catheter associated
  - Catheter related

In tunnelled CVC local infection is rarely associated with systemic infection

O’Grady et al (2011)
Exit site infection

- Erythema or induration within 2cm of exit site in absence of bloodstream infection

Tunnel infection

- Erythema or induration > 2cm from exit site

Port pocket infection

- Purulent fluid in skin pocket of implanted port

Cuff infection

Isolated infection affecting cuff
Medical adhesive related skin injury (MARSI)

- Erythema and/or vesicle, bulla, erosion or skin tear which persists 30 minutes or more after removal of dressing
  - Under reported
  - Often perceived as inevitable
- Follow manufacturer’s guidelines re application and removal of dressings
- Consider use of skin barrier and adhesive remover

Pathogenesis of systemic infection

- Migration of skin organisms at insertion site into the catheter tract with colonization of the catheter tip
- Contamination of catheter hub with intraluminal colonization
- Haematogenous seeding from other infection site
- Infusate contamination

Determining Catheter Related BSI

- Systemic infection *plus* evidence implicating the CVC as its source
  - A positive central and peripheral blood culture with isolation of the same organism with a $\geq 5:1$ ratio CVC vs peripheral
  - Isolation of the same micro-organism from at least one blood sample (preferably peripheral), and the CVC tip, with no other identifiable source of infection
  - Differential period of CVC culture vs peripheral blood culture positivity of $>2$ hours

O’Grady et al (2011)
Risk factors

- Implanted port
- Multi lumen catheter
- Daily Infusion
- Increased frequency of lipid infusion
- Increased catheter dwell time
- Compliance
- CVC for medication or blood drawing
- Opiate use
- Smoking

Treating CRBSI

- Catheter removal or attempted salvage
  - Removal indicated for fungal and staph aureus infections
  - Positive blood cultures after 48 hours of treatment
- Targeted antibiotic therapy via catheter
  - Seek microbiology guidance
- Ethanol 70% (Ball et al 2003, Metcalf et al 2004)
  - Not been associated with CVC damage (Crnich et al 2005)
  - Increasing popularity in paediatrics
CRBSI treatment in HPN

No significant difference between 7 & 10 days antibiotic treatment
CRBSI eradication dependent on the organism type
Antimicrobial prophylaxis

- First described by Messing et al (1988)
  - Higher concentrations needed to penetrate biofilm (Mermel et al 2001)

- Antimicrobial solutions
  - Taurolidine (Liu et al 2013)
    - Taurolodine™, Taurolock™, Taurosept™, Taurohep™
  - Trisodium citrate (Ko et al 2009)
    - Citra-Lock™, DuraLock-C™
  - 70% Ethanol (Tan et al 2014)
## Taurolock™ & CRBSI in HPN

<table>
<thead>
<tr>
<th>CRBSI</th>
<th>Before Taurolock™</th>
<th>After Taurolock™</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of CRBSI</td>
<td>Infection rate (per 1000 catheter days)</td>
</tr>
<tr>
<td>Definite</td>
<td>21</td>
<td>6.2</td>
</tr>
<tr>
<td>Possible</td>
<td>7</td>
<td>2.1</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>8.5</td>
</tr>
</tbody>
</table>

*p<0.05, +p<0.01, ~p<0.001

Catheter occlusion

- Thought to affect 30% CVC (Ernst 2014)
- Thrombotic or non thrombotic
- Partial, complete, or withdrawal
- Mechanical compression
  - Pinch off
  - Kink memory from clamp
- Lipid, or drug/mineral precipitate
- Blood reflux
Restoring Patency

- Fibrin deposits
  - t-PA 2mg, Urokinase 10,000 units (Atkinson et al 1990, Haire & Herbst 2000)

- Lipid deposits
  - Ethanol 70% (Pennington & Pithie 1987)

- Fibrin + lipid
  - Sodium hydroxide 0.1M (Borg et al 1993, Bader et al 2007)

- Drug/mineral precipitate
  - Hydrochloric acid 0.1M (Werlin et al 1995)

Due to the risk of CVC rupture, restoration of patency should only be attempted by suitably qualified/experienced healthcare staff.
Mechanical methods

- Endoluminal brush n=66 vs standard protocol n=68
- Standard protocol
  - Urokinase 5,000 units
- Lipid
  - 70% alcohol, Urokinase & HCl
- Electrolyte bags
  - HCl & Urokinase
- 86% vs 50% success rate (p<0.0001)

Pop technique

- Generates shock waves through the CVC loosening the obstruction
- Allows obstruction to be extracted, rather than introduced into the patient
- 94% success rate (n=50) no reported complications\(^1\)
- 86% success (n=30) no catheter damage\(^2\)

\(^1\)Stewart (2001) *Care of the critically ill* 17(3)
St Mark’s experience

- 39 occlusions (30 total, 9 partial) in 27 patients
- 8% catheters, occlusion rate 0.1 per 1000 CVC days
  - 25 patients had CVC, 2 patients ports
- Patency was restored in 38 (97%) episodes
- The 1 unsuccessful episode was total occlusion in a port which was resistant to all methods

Maintaining patency

- Sterile 0.9% sodium chloride for injection recommended for CVC in frequent use
  - Optimal volume?
- Flush lumens not used frequently at least weekly
  - Monthly for ports
- Use push pause flushing
- Positive pressure clamping

Push pause flushing

Flushing with a “stop/start” or “push-pause” motion causes turbulence of flow which may prevent the build up of deposits.

Constant flushing

Fluid in the centre moves faster than fluid in contact with the catheter walls.

“Push-pause” flushing

Fluid moves in all directions, flowing crossways and lengthways along the catheter.

Goodwin & Carlson (1993)
Push pause flushing

- Retrieval of fibronectin and albumin\(^1\)
  - 10 mL single bolus
  - 500 mL infusion/24 hours
  - 10 x 1 mL bolus (various time intervals)
  - 10 x 1 mL bolus at 0.4 sec intervals

- Retrieval of staph aureus\(^2\)
  - 10 mL single bolus
  - 10 x 1 mL bolus
  - Less colonisation in pulsed boluses, \(p<0.001\)

Clamping the catheter while injecting the last ml of fluid will prevent blood being drawn back into the catheter tip, (displacement), which could lead to occlusion, and increase the risk of catheter related infection.

Positive pressure clamping should only be used with neutral and negative displacement connectors.

INS (2011)
Blood reflux

- Syringe plunger rebound
- Negative displacement devices
- IV infusion runs dry
- Low keep vein open (KVO) rates
- Heart failure
- Respiration
- Patient movement
- Muscle contraction (PICC)
- Coughing
- Sneezing
- Vomiting

Hadaway (2005)
Syringe associated reflux

- 2 zero reflux syringes & 2 standard syringes
- 12 flushing methods
- 3 raters
- Syringe applied directly to CVC hub
- 8 Fr 60 cm 1.5mm internal diameter CVC
- Displacement measured in mm

Small et al (2014) ESPEN Abstract
## Results

<table>
<thead>
<tr>
<th></th>
<th>Zero displacement syringes</th>
<th>Standard syringes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BD Posiflush™</td>
<td>Baxa ZR™</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>6.8</td>
<td>11.1</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>40</td>
<td>46</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*p=0.0001*  

*p=0.0001*  

*p=0.1*
**Fluid displacement (mm)**

<table>
<thead>
<tr>
<th></th>
<th>Injecting part of the syringe (5 ml)</th>
<th>Injecting entire contents (10ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rater 1</td>
<td>Rater 2</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>3.8</td>
<td>6.1</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>32</td>
<td>38</td>
</tr>
</tbody>
</table>

Analysis of variance between raters was significant, $F=18.6$, $p<0.0001$, but not when some fluid was left in the syringe $F=2.7$, $p=0.07$ vs injecting the entire contents $F=28.9$, $p<0.0001$. 
<table>
<thead>
<tr>
<th>Flushing technique</th>
<th>Flush volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 No clamp, no positive pressure, remove syringe</td>
<td>1</td>
</tr>
<tr>
<td>2 Clamp, positive pressure, remove syringe</td>
<td>2</td>
</tr>
<tr>
<td>3 No clamp, positive pressure, remove syringe</td>
<td></td>
</tr>
<tr>
<td>4 Clamp, no positive pressure, remove syringe</td>
<td></td>
</tr>
<tr>
<td>5 No positive pressure, remove syringe, clamp</td>
<td></td>
</tr>
<tr>
<td>6 Positive pressure, remove syringe, clamp</td>
<td></td>
</tr>
</tbody>
</table>

Leaving some fluid in the syringe and clamping before removal had the least displacement, mean 1.05 (0-3) mm. Injecting the entire contents and not clamping before removal had the most, mean 34.4 (2-80) mm, p<0.0001.
CVC related thrombosis

- Affect 35-65% long term devices
  - Often asymptomatic

- Strategies which may influence incidence
  - Avoid dehydration
  - Use the smallest size CVC possible
  - Minimise insertion site trauma
  - Cyclical vs continuous infusion
  - Tip position
  - Tip integrity

Tip position

The risk of thrombosis is significantly increased with proximal SVC tip position.

<table>
<thead>
<tr>
<th>Catheter tip</th>
<th>Thrombosis %</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal</td>
<td>42</td>
<td>27</td>
</tr>
<tr>
<td>Intermediate</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Distal</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

48% CVC on transfer tip position too high

Tip integrity

- Trimming catheter tips has been linked with vessel perforation and thrombus formation
  - Cutting the catheter produces rough edges
- Catheters should be cut straight across according to manufacturer’s recommendations
  - Scalpels produce less irregularities than scissors

Thank you