Methods to Reduce Nosocomial Infections in Patients with Catheters

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BACKGROUND

- Central Venous Catheters are frequently used in ICU

- CVCs place patients at risk for
  - Local infections
  - Catheter-related Bloodstream Infections (CRBSI)
  - Septic thrombophlebitis
  - Endocarditis
  - Other metastatic Infections
    - Lung abscess, Brain abscess, Osteomyelitis, Endophthalmitis

BACKGROUND

- While peripheral catheters may be a source for infection, Central Venous Catheters are associate with serious catheter related infections
- ICU Unit line placement is associated with much higher incidence of infections than less acute in-patient or ambulatory settings
- ICU catheters are used for a longer period of time, manipulated multiple times for fluid, drug or other deliveries
- Catheters may be inserted on an urgent basis and thus may have less attention to aseptic technique during insertion

BACKGROUND

- In the USA, 15 million CVC days occur in ICUs each year
- If the average rate of CRBSI is 5.3 per 1000 catheter days in the ICU
- Approximately 80,000 CRBSI occur in ICUs each year
- Mortality ranges from no increase (when controlled for severity of illness) to 35% in some prospective studies
- The cost per infection is estimated at $34,508 to $56,000 thus the annual cost for caring for these pt ranges from $296 million to $2.3 billion

TERMINOLOGY

- Terminology defining different catheters is confusing.
- Descriptions involve:
  - Type of vessel it occupies (peripheral, central venous, arterial)
  - Its lifespan (temporary vs permanent)
  - The site of insertion (Subclavian, femoral, IJ, peripheral, PICC)
  - Its pathway to the vessel (tunneled vs non-tunneled)
  - Its physical length (long vs short)
  - Its special characteristics:
    - Cuffed, impregnated with heparin, antibiotics, antiseptics as well as the number of lumen

TERMINOLOGY

- Rate of ALL catheter infections (local and systemic) is difficult to determine
- CRBSI however is the ideal parameter since it is the most serious
- Catheter Infection rates depend upon how it is defined:
  - Surveillance definition: CA BSI
    - All BSI occurring in pts with CVC, when other sites of infection have been excluded. (may over estimate rate)
  - Clinical definition: CR BSI
    - Only BSIs for which other sources were excluded and a culture of the tip had substantial colonies (>15cfu) of the same organism
- CDC and JCAHO use the surveillance definition and express it as # of CABSI per 1000 CVC days

CABSI vs CRBSI Rates

Sihler KC, et al. Surg Infect 2010; 11:529-34

- Prospective collection of catheter tip cultures on all BSI over a 24 month period in all ICU
- Rates reported were markedly different depending upon the definition:
  - CA BSI = 1.4/1000 catheter days
  - CR BSI = 0.4/1000 catheter days
- CA BSI involved many organisms not associated with CR BSI

EPIDEMIOLOGY

- Rates of CRBSI varies by hospital size, hospital service/unit, and type of catheter.
- Reported ICU rates of CRBSI range from 2.9 BSI / 1000 CVC days (cardiothoracic ICU) to 11.3 BSI / 1000 CVC days (neonatal nursery in pts weighing <1,000 g)
- Relative risk of infection best measured by both BSI per 100 catheters AND BSI per 1000 CVC days. Using both will allow for hospital to hospital comparison and benchmarking

CATHETER PROTOCOLS

- Educational programs with hygiene training
- Written protocols for
  - Catheter insertion:
    - Preparation of equipment
    - Skin antisepsis
    - Detailed insertion techniques
    - Emergent catheter placements need replacement
  - Catheter manipulation:
    - Hand hygiene
    - Use of taps
  - Catheter care:
    - Replacement modalities
    - Type & frequency of dressings

Evaluation of CVC Protocol Usage in a Trauma Unit

Duane TM, et al. Am Surg 2009; 75:1166-70

- Group I–No protocol; Group II-protocol minimizing CVC use + strict universal precautions; Group III-added line supply cart and nursing check list
- While G-III had a higher injury severity score (ISS), they also had the lowest CABSI rate (GI-16.5; GII-15; GIII-7.7 per 1000 catheter days)
- After adjusting for ISS, GIII also had the shortest ICU length of stay compared to GI (12.1$\pm$1.46 vs 18.16$\pm$1.5, $p<0.03$)

Staff Education

- Training of providers who insert catheter is essential
  - Educational introduction and ongoing program
  - Simulation-based training programs are effective
- Experience of the operator is an inverse predictor of infectious rates
- Nursing staff reduction below a critical point may increase risk as adequate catheter care is difficult
- High nursing turnover or use of untrained nursing staff for specific device catheters also is associated with increase risk

Types of Catheters Used

- Catheter material used is important:
  - Biocompatible, biostable, chemically neutral, flexable
  - Good wall strength, radio-opaque, designed with a high internal to external diameter ratio, with “loc-connections”
  - Teflon or polyurethane catheters are associated with fewer infection than PVC or polyethylene
- Catheter coatings with a variety of material and catheter impregnated with antibiotics have had a variety of outcome claims and failures

Types of Catheters Used

- Catheters impregnated with chlorhexidine and silver sulfadiazine
  - Multiple randomized studies of the “first generation” catheters with extraluminal side coating compared to “standard” catheters
    - Decreased risk of catheter colonization (RR:0.59; 95%CI: 0.5-0.71)
    - Decreased risk of blood stream infections (RR:0.66; 95%CI:0.47– 0.93)
  - Several studies of “second generation” catheters with both extraluminal and intraluminal coating
    - Similar colonization risk reduction (RR:0.44; 95%CI: 0.23-0.85)
    - No meaningful reduction in blood stream risk (RR:0.7; 95%CI: 0.3 – 1.62)

Types of Catheters Used

- Several studies compared catheters covered with minocycline/rifampin to standard catheters
  - Decrease in colonization (RR: 0.4: 95%CI: 0.23-0.67)
  - Decrease in blood stream risk (RR: 0.39: 95%CI: 0.71-0.92)
- Multicenter randomized study compared catheters with ionic silver to regular catheters and found no effect on either colonization risk (RR;1.24: 95%CI: 0.83-1.85) or bloodstream prevention (RR:0.93: 95%CI: 0.35-2.44)
- Two other studies found similar results for silver coated catheters (with platinum or carbon coating).

Types of Catheters Used

- Multilumen catheters allow for simultaneous drug delivery and continued nutritional support
- Multilumen catheters help preserve future access sites and reduce the number of CVC in place.
- Compared with single lumen catheters, multilumen catheters had comparable risk of colonization (RR: 0.8; 95%CI: 0.43-1.5) but higher risk for bloodstream infections (RR: 2.26: 95%CI: 1.06-4.83)
- There is a distinction of catheter use and thus catheter infection when separating dialysis catheters from other multilumen catheters

Types of Catheters Used

- Comparing dialysis catheters to CVC in the ICU in a single center prospective descriptive study

  (Souweine, B, et al. crit care med 1999;22:2394-8)

  Infection rate was associated with the longevity of catheter placement. However, a 5 day replacement of the catheters did not alter the infection rates

  There was no difference between the dialysis catheters and the CVC in either catheter colonization nor bloodstream related infections

Dialysis catheters should be used ONLY for dialysis and should be manipulated only by dialysis-trained personnel

ACCESS SITE SELECTION

- Insertion site may influence catheter infection risk, due to differences in density of local skin flora
- A randomized study of 270 catheter placements to either the femoral or subclavian veins demonstrated a higher colonization rate (RR:2.4: 95%CI: 1.9-21.2) with femoral insertion but similar bloodstream infections (RR:2.0: 95%CI: 0.2-22.1) (Merrer J, et al. JAMA 2001; 286:700-707)
- Meta analysis of non-randomized studies comparing IJ to subclavian demonstrated a non-significant increase in colonization infections with the IJ
- Multivariate analysis in several studies have however shown increased bloodstream infections with both femoral and IJ sites
- Risk of colonization with IJ increased with body mass index < 24.2 and > 28.4

ACCESS SITE SELECTION

- Subclavian site is the preferred site from an infectious viewpoint.
- Potential mitigating factors remain in site selection:
  - Potential for insertion complications in specific patient types and disease
  - Insertion technique or catheter type
  - Risk of subclavian vein stenosis
  - Catheter operator skill
  - Pediatric vs adult patient population
- When choosing other than subclavian, insertion to IJ or Femoral choice should be made on body mass index of the patient and the use of the catheter inserted

Insertion Techniques and Considerations

- The level of barrier protection for CVC insertion needs to be more stringent
- Hand hygiene is first line of defense
- Maximal sterile precautions (cap, mask, sterile gown, sterile gloves, large sterile drapes) reduces the incidence of CRBSI compared to standard precautions (sterile gloves and small drapes).
- Application of the above precautions to PICC insertion has not been demonstrated, yet it also is recommended

Insertion Techniques and Considerations

- Skin Antisepsis
  - Povidone iodine and chlorhexidine are the most used agents
  - Number of comparative studies have been performed
  - In all studies, the use of chlohexidine (in a variety of solutions and combinations) had a superior reduction in CRBSI over the use of povidone iodine.
  - When using povodone iodine, the alcoholic preparation was superior to standard solution in both catheter colonization and CRBSI

Insertion Techniques and Considerations

- Catheter site dressing requirements
  - Transparent semipermiable polyurethane dressings are popular
    - Fix the site, allow for visualization, allow “bathing”, less frequent changing required
  - Chlorhexidine-impregnated sponge dressing
    - Reduced the risk of colonization and CRBSI in short-term catheters
    - Contact dermatitis is occasionally seen
    - Rare sever anaphylactic reactions have been reported
- Catheter Securement Devices
  - Sutureless securement is preferable to sutures to lower colonization and CRBSI
  - Sutures when used should allow for some lateral movement but not for exit/entry movement

Insertion Techniques and Considerations

- Silver Cuff Catheters
  - Theoretically should reduce migration
  - With catheters left in place for >20 days, there is no improvement in colonization or CRBSI
  - Studies on short-term catheter also showed no improvement
- Antibiotic/antiseptic ointments
  - Providone-iodine ointment applied to the insertion sites of dialysis catheters as a prophylactic method of reducing infection risk. Compared to no ointment, there is a reduction of exit site infection, catheter tip infection and CRBSI
  - Mupirocin ointment applied to site or to nasal carriers (S.aureus) however resistance by coag-neg staph and s.aureus is seen

Insertion Techniques and Considerations

- Antibiotic/Antimicrobial prophylaxis
  - Use of systemic antibiotics have been associated with a reduction of CRBSI but have also been associated with the emergence of resistant organisms. Thus this has been discouraged
  - Catheter lock solutions
    - Vancomycin/ciprofloxacin vs vancomycin : both reduce vancomycin sensitive infections but are prone to resistant generation
    - Minocycline and EDTA has been used but not good prospective study supports its effectiveness
    - Citrate solutions (43%) lock has been abandoned altogether

Insertion Techniques and Considerations

- Subcutaneous Tunneling
  - Increases the distance between the venous entry site and the skin emergence
  - Improved fixation of the catheter
  - Reduces infection in short-term catheters where infection arises from skin contaminants.
  - Randomized control trial showed tunneling to be associated with 39% lower colonization rate and 44% reduction in CRBSI compared to non-tunneled catheters (Randolph et al. crit care med 1998: 26:1452-1457)
  - Data however does not support routine tunneling for short-term catheters unless:
    - Subclavian is not used
    - Duration of catheter is anticipated to be > 7 days

CATHETER REPLACEMENT

- Catheter replacement at scheduled times (every 7 days) has not lowered infection rates over catheter changes as needed
- Routine catheter changes over guidewires have also not been associated with lower infection rates. Indeed, some studies have noted an increase in colonization especially when insertion techniques are altered.
- Malfunctioning catheter replacement over guidewire is acceptable but not in the face of a bacteremia.
- Site salvage is a factor which needs to be considered

CATHETER MANIPULATION

- Replacement of administration sets
  - Schedules replacement on a 72 h interval is both safe and cost-effective
  - When fluids which enhance growth are infused (lipids emotions or blood products) more frequent set changes are suggested
- Stopcocks
  - Stopcock contamination is common, occurring in 45-50% in the majority of series
  - “piggyback” systems are an alternative but close attention to adequate preparation of the entry point is needed
- Needleless Systems
  - When used according to manufacturers suggestions they are safe. When replacement caps are reduced, greater risk is found

CONCLUSION

- Strict attention to hygiene is the primary barrier to infection. This includes full drapes and sterile techniques during both insertion and replacement
- Establish a check-list and provide adequate training and a strict protocol for catheter insertion
- Minimize catheter entry and identify appropriate schedules changes for lines, etc
- No need for routine catheter changes
- Tunneling may provide a barrier when using IJ or Femoral sites

CONCLUSION

- Treat entry sites of dialysis catheters with povidine iodine ointment and transparent dressing
- Dialysis catheters should be used ONLY for dialysis and not as a port for other uses
- Avoid triple lumen dialysis catheter to reduce catheter manipulation
- Locking techniques have not been universally accepted
- Antibiotic prophylaxis has not been associated with major reduction in infection and may herald resistance
- Replace emergently placed catheters once patient is stable

- Compulsive behavior is rewarded while passive aggressive approaches create confusion