

**SECTION A: EXECUTIVE SUMMARY**

- I. Antibiotic lock therapy (ALT) is most commonly considered for adjunctive treatment of bacteremia associated with central venous catheters (CVC).
- II. ALT can also be considered for prophylaxis of bacteremia for certain populations.

**SECTION B: ANTIBIOTIC LOCK THERAPY (ALT)**

**I. KEY CONCEPTS**

- a. ALT is most commonly used for adjunctive treatment of bacteremia associated with CVC when the CVC is not removed.
- b. Prophylactic use of ALT may be considered for select patients, e.g. patients deemed at high risk for recurrent bloodstream infection.
- c. ALT is not intended to be administered via the routes of IV infusion or IV push.
- d. Usual dwell time is 4-24 hours. Duration of dwell time should not exceed 24 hours (see IV: Dwell Time and Exchange Frequency).

**II. PATIENT ELIGIBILITY**

- a. Bacteremia associated with central venous catheter (CVC)
- b. Prophylaxis for recurrent blood stream infections (BSIs) in high-risk patients
- c. Prior to initiating ALT, all ALT candidates require consultation and approval by Infectious Diseases Consult Service

**III. CONTRAINDICATIONS**

- a. History of heparin-induced thrombocytopenia (HIT) for ALT-containing heparin. Gentamicin lock is an exception as it does not contain heparin.
- b. Allergy to any component in the lock.
- c. Personal or religious exclusion to ingestion of pork components *if* lock contains heparin. Gentamicin lock is an exception as it does not contain heparin.
- d. Catheter tunnel or exit site infect.

**IV. ALT Doses**

- a. ALT recipes listed in Appendix C
- b. Other antibiotic locks may be considered per Infectious Diseases as needed

Antibiotic	Antibiotic Concentration	Additive Concentration	Stability
Cefazolin	10 mg/mL	Heparin 10 units/mL	30 hours
Ceftazidime	10 mg/mL	Heparin 10 units/mL	30 hours
Gentamicin	2.5 mg/mL	Sodium Citrate 40 mg/mL (4%)	30 hours
Linezolid	1 ml/mL	Heparin 10 units/mL	30 hours
Vancomycin	2 mg/mL	Heparin 10 units/mL	30 hours

c. Catheter and Volume Selection

Catheter Type	Volume per lumen
PICC, Tunneled or Non-Tunneled Central catheter (e.g. Broviac)	2 mL
Implanted Vascular Access Port (e.g. Port-A-Cath)	5 mL

d. Dwell Time and Exchange Frequency

1. Range of dwell time is 4-24 hours. Duration of dwell time should not exceed 24 hours. Lock solution should generally remain in place (dwelling) whenever the affected line/lumen is not in use. The number of ALT exchanges per day should be coordinated between pharmacy and the RN.
2. Pharmacy and nursing should work to cluster required medications and/or lab draw times to minimize catheter use and maximize ALT dwell times.

## V. PHARMACY OPERATIONS

- a. Pharmacy to send 2 mL of antibiotic lock solution in a 10 mL syringe for each lumen of a PICC, Tunneled or Non-Tunneled Central catheter (e.g. Broviac)
- b. Pharmacy to send 5 mL of antibiotic lock solution in a 10 mL syringe for each lumen of an implanted Vascular Access Ports (e.g. Port-A-Cath)
- c. Heparinized antibiotic locks to be formulated with normal saline only.
- d. Storage: Room temperature (23-25°C).  
Label warnings: For antibiotic lock therapy into CVC lumen only

## VI. NURSING ADMINISTRATION

a. **To place antibiotic lock therapy:**

1. Verify patient and procedure using 2 patient identifiers.
  2. Perform hand hygiene. Don clean gloves.
  3. Vigorously scrub the needleless connector for 10 seconds with alcohol pad and allow to dry for 10 seconds.
  4. If ALT in place, attach a 10 mL syringe and aspirate volume of lock plus 1-2 mLs to remove any clots at the tip. Remove syringe and discard. Repeat step 3. If no ALT in place, proceed to step 5.
  5. Attach a pre-filled normal saline syringe and flush CVC with 10mL of normal saline; remove and discard syringe.
  6. Vigorously scrub the needleless connector for 10 seconds with alcohol pad and allow to dry for 10 seconds.
  7. Attach ALT syringe onto injection cap.
  8. Instill ALT solution to fill CVC lumen. Remove empty syringe.
  9. Clamp catheter and allow antibiotic lock to dwell 4 hours minimum. Longer dwell times are considered better. Notify ID and the primary service if not able to dwell minimum of 4 hours per 24 hour period.
- b. Label the CVC lumen that has the lock instilled in it: " DO NOT USE- Antibiotic Lock In Place"

- c. Document in APeX which line and/or lumen has an antibiotic lock; lumen color/locality should be entered as a comment in the lock administration on the eMAR.
- d. **When dwell time is complete, aspirate volume of ALT from CVC lumen.**
- e. Attach a pre-filled normal saline syringe and flush CVC with 10mL of normal saline; then remove and discard syringe.
- f. Vigorously scrub the needleless connector for 10 seconds with alcohol pad and allow to dry for 10 seconds
  1. IF instilling a subsequent day/dose ALT, return to step a6.
  2. IF utilizing the lumen for an infusion, attach tubing per procedure.
  3. IF ALT therapy complete and no needed infusions, heparinize catheter per provider order.

## VII. Guideline Working Group

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## VIII. Guideline History:

**Initial Guideline Developed and Approved by the Pharmacy and Therapeutics Committee: 12/2020**  
**Minor revision in verbiage: 01/2023**

Appendix C: Antibiotic Lock Recipes

<b>Cefazolin 10 mg/mL + Heparin 10 units/mL</b>	
<b>Materials and Equipment</b>	Syringes: 5 mL(1), 10 mL (2), 20 mL (1) Needles: 19 to 21 gauge (1) Miscellaneous: Alcohol wipes, labels, syringe cap
<b>Pharmaceuticals</b>	Cefazolin Powder for Injection 500mg vial (1) Heparin Lock Flush Injection 100 units/mL Pre-Filled Syringe (1) Bacteriostatic Normal Saline vial (1)
<b>Compounding</b>	1. Clean all surfaces with 70% isopropyl alcohol 2. Assemble all pharmaceuticals and materials
<b>To prepare 10 mg/mL antibiotic lock solution</b>	<p><u>TWO MILLILITER LOCK SOLUTION</u></p> <ol style="list-style-type: none"> <li>1. Reconstitute 500 mg Cefazolin vial with 4.5 mL Bacteriostatic NS. This results in a concentration of 100 mg/mL</li> <li>2. Add 1 mL of Cefazolin 100 mg/mL (100 mg) to the 20 mL syringe</li> <li>3. Add 8 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter”</li> <li>4. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe</li> <li>5. Agitate solution</li> <li>6. Transfer 2 mL of Cefazolin -Heparin solution to a 10 mL syringe</li> <li>7. Label with 30-hour expiration date</li> </ol> <p><u>FIVE MILLILITER LOCK SOLUTION</u></p> <ol style="list-style-type: none"> <li>1. Reconstitute 500 mg Cefazolin vial with 4.5 mL Bacteriostatic NS. This results in a concentration of 100 mg/mL</li> <li>2. Add 1 mL of Cefazolin 100 mg/mL (100 mg) to the 20 mL syringe</li> <li>3. Add 8 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter”</li> <li>4. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe</li> <li>5. Agitate solution</li> <li>6. Transfer 5 mL of Cefazolin-Heparin solution to a 10 mL syringe</li> </ol> <p>Label with 30 hour expiration date</p>
<b>Beyond Use Dating</b>	30 hours at room temperature, prepare on demand
<b>Stability</b>	<ul style="list-style-type: none"> <li>• The stability of heparin (10 units/mL) was evaluated (per change in APTT) by combining cefazolin 10 mg/mL</li> <li>• Incubated in the dark at 4°C and 37°C</li> <li>• No clinically significant biological effect on heparin was noted, and solutions were visually physically compatible for 14 days</li> </ul>
<b>Reference(s)</b>	Robinson, J. L., Tawfik, G., Saxinger, L., Stang, L., Etches, W., & Lee, B. (2005). Stability of heparin and physical compatibility of heparin/antibiotic solutions in concentrations appropriate for antibiotic lock therapy. <i>Journal of Antimicrobial Chemotherapy</i> , 56(5), 951–953. <a href="https://doi.org/10.1093/jac/dki311">https://doi.org/10.1093/jac/dki311</a>

## Antibiotic Lock Therapy Adult Guidelines

### Ceftazidime 10 mg/mL + Heparin 10 units/mL

<b>Materials and Equipment</b>	Syringes: 5 mL(1), 10 mL (2), 20 mL (1) Needles: 19 to 21 gauge (1) Miscellaneous: Alcohol wipes, labels, syringe cap																				
<b>Pharmaceuticals</b>	Ceftazidime Powder for Injection 500mg vial (1) Heparin Lock Flush Injection 100 units/mL Pre-Filled Syringe (1) Bacteriostatic Normal Saline vial (1)																				
<b>Compounding</b>	1. Clean all surfaces with 70% isopropyl alcohol Assemble all pharmaceuticals and materials																				
<b>To prepare 10 mg/mL antibiotic lock solution</b>	<p><b>TWO MILLILITER LOCK SOLUTION</b></p> <ol style="list-style-type: none"> <li>1. Reconstitute 500 mg Ceftazidime vial with 5.3 mL Bacteriostatic NS. This results in a concentration of 100 mg/mL</li> <li>2. Add 1 mL of Ceftazidime 100 mg/mL (100 mg) to the 20 mL syringe</li> <li>3. Add 8 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter”</li> <li>4. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe</li> <li>5. Agitate solution</li> <li>6. Transfer 2 mL of Ceftazidime-Heparin solution to a 10 mL syringe</li> <li>7. Label with 30-hour expiration date</li> </ol> <p><b>FIVE MILLILITER LOCK SOLUTION</b></p> <ol style="list-style-type: none"> <li>1. Reconstitute 500 mg Ceftazidime vial with 5.3 mL Bacteriostatic NS. This results in a concentration of 100 mg/mL</li> <li>2. Add 1 mL of Ceftazidime 100 mg/mL (100 mg) to the 20 mL syringe</li> <li>3. Add 8 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter”</li> <li>4. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe</li> <li>5. Agitate solution</li> <li>6. Transfer 5 mL of Ceftazidime-Heparin solution to a 10 mL syringe</li> </ol> <p>Label with 30-hour expiration date</p>																				
<b>Beyond Use Date</b>	30 hours at room temperature, prepare on demand																				
<b>Stability</b>	<p>10mg/mL and heparin 10 units/mL at UCSF Medical Center Hospital Pharmacy</p> <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Ceftazidime 10 mg/mL</th> <th colspan="4" style="text-align: left;">Heparin 10 units/mL</th> </tr> <tr> <th style="text-align: left;">Day</th> <th style="text-align: center;">0</th> <th style="text-align: center;">1</th> <th style="text-align: center;">3</th> <th style="text-align: center;">7</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">37°C</td> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> </tr> <tr> <td style="text-align: left;">25°C</td> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> <td style="text-align: center;">C</td> </tr> </tbody> </table>	Ceftazidime 10 mg/mL	Heparin 10 units/mL				Day	0	1	3	7	37°C	C	C	C	C	25°C	C	C	C	C
Ceftazidime 10 mg/mL	Heparin 10 units/mL																				
Day	0	1	3	7																	
37°C	C	C	C	C																	
25°C	C	C	C	C																	
<b>Reference(s)</b>																					

## Antibiotic Lock Therapy Adult Guidelines

### Gentamicin 2.5 mg/mL + Sodium Citrate 40 mg/mL (4%)

<b>Materials and Equipment</b>	Syringes: 5 mL(1), 10 mL (2) Miscellaneous: Alcohol wipes, labels, syringe cap
<b>Pharmaceuticals</b>	Gentamicin 40 mg/mL (2 mL vial) (1) Sodium Citrate 4% (40 mg/mL) (3 mL syringe) (2)
<b>Compounding</b>	<ol style="list-style-type: none"> <li>Clean all surfaces with 70% isopropyl alcohol</li> </ol> Assemble all pharmaceuticals and materials
<b>To prepare 2 mg/mL antibiotic lock solution</b>  <b>To prepare 5 mg/mL antibiotic lock solution</b>	<u>TWO MILLILITER LOCK SOLUTION</u> <ol style="list-style-type: none"> <li>Attach a “universal syringe tip adapter” to Sodium Citrate 4% syringe. Attach a 5 mL syringe. Add 2.8 mL Sodium Citrate 4% into the 5 mL syringe.</li> <li>Add 0.2 mL of Gentamicin 40 mg/mL to the 5 mL syringe.</li> <li>Cap and shake well to get uniform dilution.</li> <li>Transfer 2 mL of Gentamicin-Sodium Citrate solution to a 10 mL syringe.</li> <li>Label with 30-hour expiration date.</li> </ol> <u>FIVE MILLILITER LOCK SOLUTION</u> <ol style="list-style-type: none"> <li>Attach a “universal syringe tip adapter” to Sodium Citrate 4% syringe. Attach a 10 mL syringe. Add 5.6 mL Sodium Citrate 4% into 10 mL syringe.</li> <li>Add 0.4 mL of Gentamicin 40 mg/mL to the 10 mL syringe.</li> <li>Cap and shake well to get uniform dilution.</li> <li>Transfer 5 mL of Gentamicin-Sodium Citrate solution to a 10 mL syringe.</li> <li>Label with 30-hour expiration date.</li> </ol>
<b>Beyond Use Date</b>	30 hours at room temperature, prepare on demand
<b>Stability</b>	<ul style="list-style-type: none"> <li>The stability of the gentamicin 2.5 mg/mL + Sodium Citrate 40 mg/ml combination were assessed by HPLC.</li> <li>Incubated in a plastic bin with an opaque, snug-fitting lid.</li> <li>Results indicate stability for at least 112 days at room temperature.</li> </ul>
<b>Reference(s)</b>	Cote D, Lok CE, Battistella M et al. Stability of Trisodium Citrate and Gentamicin Solution for Catheter Locks after Storage in Plastic Syringes at Room Temperature. Can J Hosp Pharm. 2010; 63:304-11.

## Antibiotic Lock Therapy Adult Guidelines

<b>Linezolid 1 mg/mL + Heparin 10 units/mL</b>	
<b>Materials and Equipment</b>	Syringes: 5 mL(1), 10 mL (2), 20 mL (1) Needles: 19 to 21 gauge (1) Miscellaneous: Alcohol wipes, labels, syringe cap
<b>Pharmaceuticals</b>	Linezolid Pre-made Infusion 200mg/100mL bag (1) Heparin Lock Flush Injection 100 units/mL Pre-Filled Syringe (1) Bacteriostatic Normal Saline vial (1)
<b>Compounding</b>	1. Clean all surfaces with 70% isopropyl alcohol 2. Assemble all pharmaceuticals and materials
<b>To prepare 1 mg/mL antibiotic lock solution</b>	<p><b>TWO MILLILITER LOCK SOLUTION</b></p> <ol style="list-style-type: none"> <li>1. Add 5 mL Linezolid 2 mg/mL (10 mg) to a 20 mL syringe</li> <li>2. Add 4 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter”</li> <li>3. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe</li> <li>4. Agitate solution</li> <li>5. Transfer 2 mL of Linezolid-Heparin solution to a 10 mL syringe</li> <li>6. Label with 30-hour expiration date</li> </ol> <p><b>FIVE MILLILITER LOCK SOLUTION</b></p> <ol style="list-style-type: none"> <li>1. Add 5 mL Linezolid 2 mg/mL (10 mg) to a 20 mL syringe</li> <li>2. Add 4 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter”</li> <li>3. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe</li> <li>4. Agitate solution</li> <li>5. Transfer 5 mL of Linezolid-Heparin solution to a 10 mL syringe</li> </ol> <p>Label with 30-hour expiration date</p>
<b>Beyond Use Date</b>	30 hours at room temperature, prepare on demand
<b>Stability</b>	<ul style="list-style-type: none"> <li>• Linezolid (2 mg/mL) initially evaluated alone and subsequently evaluated in combination of heparin at a concentration of 10 units/mL for 72 hr. Incubated at 37°C</li> <li>• Stabilities of antimicrobials assessed by bioassay</li> <li>• Inclusion of heparin at a concentration of 10 units/mL did not impair activity of linezolid against the biofilm</li> </ul>
<b>Reference(s)</b>	<p>Curtin, J., Cormican, M., Fleming, G., Keelehan, J., &amp; Collieran, E. (2003). Linezolid compared with eperezolid, vancomycin, and gentamicin in an in vitro model of antimicrobial lock therapy for Staphylococcus epidermidis central venous catheter-related biofilm infections. <i>Antimicrobial Agents and Chemotherapy</i>, 47(10), 3145–3148. <a href="https://doi.org/10.1128/AAC.47.10.3145-3148.2003">https://doi.org/10.1128/AAC.47.10.3145-3148.2003</a></p> <p>Droste, J. C., Jeraj, H. A., MacDonald, A., &amp; Farrington, K. (2003). Stability and in vitro efficacy of antibiotic-heparin lock solutions potentially useful for treatment of central venous catheter-related sepsis. <i>Journal of Antimicrobial Chemotherapy</i>, 51(4), 849–855. <a href="https://doi.org/10.1093/jac/dkg179">https://doi.org/10.1093/jac/dkg179</a></p>

## Antibiotic Lock Therapy Adult Guidelines

<b>Vancomycin 2 mg/mL + Heparin 10 units/mL</b>	
<b>Materials and Equipment</b>	Syringes: 5 mL(1), 10 mL (2), 20 mL (1) Needles: 19 to 21 gauge (1) Miscellaneous: Alcohol wipes, labels, syringe cap
<b>Pharmaceuticals</b>	Vancomycin Powder for Injection 500mg vial (1) Heparin Lock Flush Injection 100 units/mL Pre-Filled Syringe (1) Bacteriostatic Normal Saline vial (1) Normal Saline 100mL bag (1)
<b>Compounding</b>	2. Clean all surfaces with 70% isopropyl alcohol Assemble all pharmaceuticals and materials
<b>To prepare 2 mg/mL antibiotic lock solution</b>	<p><u>TWO MILLILITER LOCK SOLUTION</u></p> <ol style="list-style-type: none"> <li>6. Add 5 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter.”</li> <li>7. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe.</li> <li>8. Cap and shake well to get uniform dilution.</li> <li>9. Remove and waste 10 mL from NS 100 mL bag.</li> <li>10. Reconstitute 500 mg Vancomycin vial with 10 mL NS from bag and add back to bag. This results in a concentration of 5 mg/mL.</li> <li>11. Draw 4 mL of Vancomycin 5mg/mL (20 mg total) into a syringe.</li> <li>12. Slowly add 4 mL of Vancomycin 5 mg/mL (20 mg) to the 20 mL syringe with agitation.</li> <li>13. Transfer 2 mL of Vancomycin-Heparin solution to a 10 mL syringe.</li> <li>14. Label with 30-hour expiration date.</li> </ol> <p><u>FIVE MILLILITER LOCK SOLUTION</u></p> <ol style="list-style-type: none"> <li>6. Add 5 mL Bacteriostatic NS to the 20 mL syringe. Attach a “universal syringe tip adapter.”</li> <li>7. Add 1 mL Heparin 100 units/mL (100 units) to the 20 mL syringe.</li> <li>8. Cap and shake well to get uniform dilution.</li> <li>9. Remove and waste 10 mL from NS 100 mL bag.</li> <li>10. Reconstitute 500 mg Vancomycin vial with 10 mL NS from bag and add back to bag. This results in a concentration of 5 mg/mL.</li> <li>11. Draw 4 mL of Vancomycin 5mg/mL (20 mg total) into a syringe.</li> <li>12. Slowly add 4 mL of Vancomycin 5 mg/mL (20 mg) to the 20 mL syringe with agitation.</li> <li>13. Transfer 5 mL of Vancomycin-Heparin solution to a 10 mL syringe.</li> </ol> <p>Label with 30-hour expiration date.</p>
<b>Beyond Use Date</b>	30 hours at room temperature, prepare on demand
<b>Stability</b>	<ul style="list-style-type: none"> <li>• The stability of heparin (10 units/mL) was evaluated (per change in aPTT) by combining vancomycin 2.5 mg/mL.</li> <li>• Incubated in the dark at 4°Celsius and 37°Celsius</li> <li>• No clinically significant biological effect on heparin was noted, and solutions were visually physically compatible for 14 days.</li> </ul>
<b>Reference(s)</b>	Robinson, J. L., Tawfik, G., Saxinger, L., Stang, L., Etches, W., & Lee, B. (2005). Stability of heparin and physical compatibility of heparin/antibiotic solutions in concentrations appropriate for antibiotic lock therapy. <i>Journal of Antimicrobial Chemotherapy</i> , 56(5), 951–953. <a href="https://doi.org/10.1093/jac/dki311">https://doi.org/10.1093/jac/dki311</a>



**IX. REFERENCES**

- a. Bookstaver PB, Rokas KE, Norris LB, Edwards JM, Sherertz RJ. Stability and compatibility of antimicrobial lock solutions. *Am J Health Syst Pharm.* 2013;70(24):2185-98.
- b. Bookstaver, B., & Justo, J. A. (2014). Antibiotic lock therapy: review of technique and logistical challenges. *Infection and Drug Resistance*, 343. <https://doi.org/10.2147/idr.s51388>
- c. Carratalà J. Role of antibiotic prophylaxis for the prevention of intravascular catheter-related infection. *Clin Microbiol Infect.* 2001;7 Suppl 4:83-90.
- d. Centers for Disease Control and Prevention. Guidelines for the Prevention of Intravascular Catheter-Related Infections, 2011. <https://www.cdc.gov/hai/pdfs/bsi-guidelines-2011.pdf>. Accessed June 8, 2018.
- e. Cote D, Lok CE, Battistella M et al. Stability of Trisodium Citrate and Gentamicin Solution for Catheter Locks after Storage in Plastic Syringes at Room Temperature. *Can J Hosp Pharm.* 2010; 63:304-11.
- f. Haimi-Cohen Y, Husain N, Meenan J, et al. Vancomycin and ceftazidime bioactivities persist for at least 2 weeks in the lumen in ports: simplifying treatment of port-associated bloodstream infections by using the antibiotic lock technique. *Antimicrob Agents Chemother.* 2001;45(5):1565-7.
- g. Justo JA, Bookstaver PB. Antibiotic lock therapy: review of technique and logistical challenges. *Infect Drug Resist.* 2014;7:343-63.
- h. Mermel LA, Allon M, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infections 2009 update. *Clinical Infectious Diseases* 2009;49:1-45.
- i. Pietruszka, M. University of Wisconsin Hospital and Clinics Guidelines for Anti-Infective Lock Solutions. Approved 1/2011.
- j. Stanford Hospital and Clinics. Antibiotic Lock Therapy Guideline. Reviewed 01/2015.
- k. Yokoyama H, Aoyama T, et al. The cause of polyurethane catheter cracking during constant infusion of etoposide (VP-16) injection. *Yakagaku Zasshi.* 1998;118:581-88.