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| **PROTOCOL: Vancomycin Collaborative Practice Dosing Protocol** | |
| **CATEGORY:** Clinical | **Date Originated:** 10/25/13 |
| **Page** 1 of 23 | **Last Reviewed:** 10/2020 |
| **Owner:** Director of Pharmacy, Dept. of Infectious Diseases | **Last Revised:** 10/2020 |
| **Approved by:** Pharmacy & Therapeutics Committee, Medical Staff Executive Committee | **Retired:** |

**Collaborative Practice Agreement for Intravenous (IV) Vancomycin drug management, dosing, and monitoring**

**[Original Approval by Pharmacy & Therapeutics Committee 10/30/13]**

**1.) SCOPE:**

* Licensed Prescribers, Pharmacists, Nurses. All Pharmacists who have received, completed, and passed the internal competency certification on Vancomycin clinical management.
* Population: Adult Patients with orders for IV Vancomycin initiated either in the Emergency Department or in Inpatient Care Units
* Outcome: Pharmacists will independently manage IV Vancomycin therapy according to the guidelines detailed in this protocol

**2.) COLLABORATIVE PRACTICE AGREEMENT:**

* Under this collaborative practice agreement, UConn Health – John Dempsey Hospital Pharmacists, according to and in compliance with ***Section 91 of Public Act 10-7 and Connecticut General Statutes sec 20-631 “An Act Concerning Collaborative Practice Between Physicians and Pharmacists”***, may design, implement, and monitor a therapeutic drug plan intended to manage IV Vancomycin therapy upon receipt of an order from the licensed provider to the Pharmacist for IV Vancomycin dosing.
* The specific services provided by the Pharmacists and the methods for providing these services are described in detail in this protocol document

**3.) PURPOSE:**

1. To establish evidence-based guidelines for the dosing and monitoring of IV Vancomycin therapy based on current peer-reviewed literature.
2. To provide a detailed and standardized protocol that allows Pharmacists to manage IV vancomycin therapy in collaboration with practitioners.
3. To maximize the probabilities that patients will receive optimized IV vancomycin therapy which not only maximizes its efficacy but also minimizes its risks of toxicities.

**4.) BACKGROUND: CONTEMPORARY CLINICAL USE OF VANCOMYCIN:**

Vancomycin was the first glycopeptide antibiotic developed for clinical use in the United States.  Glycopeptides exhibit their antibacterial activity primarily via inhibition of the late stages of cell wall synthesis, but inhibition of RNA synthesis and disruption of the cytoplasmic membrane has also been described in *Staphylococcus aureus* isolates.  Vancomycin has broad activity against nearly all gram-positive aerobic microorganisms, most notably methicillin-resistant *Staphylococcus aureus* (MRSA) (1).  Although high-level resistance to vancomycin (defined as minimum inhibitory concentrations (MICs) of > 4 mg/L) is now present in approximately 20% of clinical strains of Enterococcus, nearly all Staphylococci still remain susceptible to vancomycin, with MICs ranging from 0.125 to 2 mg/L (1).

For nearly six decades since its approval for clinical use in 1958, the usual recommended intravenous dose of vancomycin in adults with normal renal function was 30 mg/kg per day, divided into 2 or 4 doses (typical regimens were 500 milligrams every 6 hours or 1 gram every 12 hours in patients with normal body weight).  These doses usually resulted in vancomycin serum trough concentrations of between 5-10 mg/L, and concentrations within this range were considered as the “therapeutic” (target) range for the antibiotic, given its very short (<2 h) post-antibiotic effect against gram-positive bacteria (2).  Vancomycin trough concentrations in this range resulted in high clinical cure rates for most systemic infections and were also associated with a < 10% prevalence of nephrotoxicity--the primary adverse effect for the antibiotic (2).

However, around the mid-to-late 2000’s, a number of epidemiologic investigations were published that documented a substantial increase in the most commonly-observed MRSA vancomycin MICs--from a historic range of 0.125-0.5 mg/L to a range of 1-2 mg/L (3).  This increase in MICs (termed the “MIC Creep” phenomenon) also began to be described as a possible contributor to therapeutic failures of vancomycin therapy in sporadic case reports. A systematic review and meta-analysis of various publications years reported a statistically-significant association of MRSA vancomycin MIC of > 1.5 mg/L with increased mortality (4). This finding was described as “irrespective of the source of infection”, but in reality, it was predominantly driven by poorer outcomes in serious systemic infections such as bacteremia, endocarditis, and pneumonia (4).

The first consensus guideline for therapeutic monitoring of vancomycin in adult patients was published in 2009 (3). In it, a vancomycin AUC/MIC ratio of > 400 mg-h/L was emphasized as the primary predictor of activity.  Because determining the AUC/MIC was impractical in most care sites at that time, a serum trough concentration range of 10-20 mg/L (with 15-20 mg/L for “serious” MRSA infections) was suggested as a surrogate marker for achieving this AUC/MIC.

The consensus guidelines were revised in 2020 to reflect approximately 10 years of additional published research data on vancomycin activity and safety (5). The most important new information and recommendations are:

1. Vancomycin MIC creep has appeared to have “leveled off” or has even decreased nationwide; most MRSA in most U.S. hospitals will have vancomycin MICs of 1 mg/L.
2. Additional data on pharmacokinetics is now available for certain important special populations; improved approaches to dosing and monitoring vancomycin in patients with extreme obesity, renal failure, renal replacement, and/or critical illness are included in the new guidelines.
3. Additional data now support a preference for either estimating or calculating an actual AUC/MIC as it appears to be a more accurate predictor of vancomycin efficacy and toxicity than a serum trough concentration :
   * The achievement of an AUC/MIC of > 400 within the first 48 hours of therapy is associated with improved outcomes in patients with documented serious MRSA infections
   * AUC/MIC values of >600 appear to be associated with higher risks of vancomycin-associated nephrotoxicity
   * Serum trough concentrations of 10-20 mg/L are not as accurate a predictor of achieving an AUC/MIC of 400-600 as originally thought.

**A.) Overview of Recommendations for Dosing & Monitoring per the 2020 Consensus Guidelines:**

*“Based on the current best available evidence, daily vancomycin AUC values (assuming a MIC of 1 mg/L) should be maintained between 400 and 600 mg·h/L**to minimize the likelihood of nephrotoxicity and maximize efficacy for suspected or definitive serious invasive MRSA infections.* ***Once culture results or the clinical presentation rule out invasive MRSA infection, the empiric use of vancomycin at guideline recommended exposures should be de-escalated, either by a decrease in vancomycin exposure or initiation of alternative antibiotics.*** *Extrapolation of guideline recommendations to noninvasive MRSA and other pathogens should be viewed with extreme caution.”*

**Loading Doses and Initial Dosing Regimens:**

*“In order to achieve rapid attainment of targeted concentrations in critically ill patients with suspected or documented serious MRSA infections,**a loading dose of 20 to 35 mg/kg can be considered for intermittent-infusion administration of vancomycin (B-II).* Loading doses should be based on actual body weight and not exceed 3,000 mg.”

*“...using* ***actual body weight–based loading doses of 20 to 25 mg/kg*** *(doses lower than previously recommended),* ***with consideration of capping doses at 3,000 mg, is the most practical strategy in obese patients with serious infections.****”*

*“Doses of 15 to 20 mg/kg (based on actual body weight) administered every 8 to 12 hours as an intermittent infusion are recommended for most patients with normal renal function”*

**Therapeutic Monitoring of the AUC/MIC:**

*“Vancomycin monitoring is recommended for patients receiving vancomycin for serious MRSA infections to achieve sustained targeted AUC values [...] Independent of MRSA infection, vancomycin monitoring is also recommended for all patients at high risk for nephrotoxicity (eg, critically ill patients receiving concurrent nephrotoxins), patients with unstable (ie, deteriorating or significantly improving) renal function, and those receiving prolonged courses of therapy (more than 3 to 5 days).”*

*“One approach relies on the collection of 2 concentrations (obtained near steady-state, post distributional peak concentration [Cmax] at 1 to 2 hours after infusion and trough concentration [Cmin] at the end of the dosing interval), preferably but not required during the same dosing interval (if possible) and utilizing first-order PK equations to estimate the AUC (A-II).”*

*“Given the importance of early, appropriate therapy, vancomycin targeted exposure should be achieved early during the course of therapy, preferably within the first 24 to 48 hours (A-II).”*

*“More intensive therapeutic monitoring should also be performed in obese patients. [...] Measurement of peak and trough concentrations is recommended to improve the accuracy of vancomycin AUC estimation and maintenance dose optimization in obese patients”*

**B.) Current Status of Vancomycin MICs in MRSA isolates at UConn Health John Dempsey Hospital:**

A query of all MRSA isolates was obtained from the Clinical Microbiology laboratory database. The following trends in MICs occurred from 2018-2020:

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| **Year** | **Total Samples** | **% MIC <1 mg/L** | **% MIC = 2 mg/L** |
| 2018 | 166 | 64% | 36% |
| 2019 | 218 | 81% | 19% |
| 2020 (through Aug.) | 95 | 90% | 10% |

**Justification for the Initial Implementation of a Vancomycin Collaborative Practice Protocol at UConn Health John Dempsey Hospital:**

Due to the observations of suboptimal achievement of maximally-effective and maximally-safe vancomycin therapy in our patients at UConn Health John Dempsey Hospital under current clinical practice standards, we now propose a highly-detailed, evidence-based, and rigorously-structured *Collaborative Practice Protocol* to guide Pharmacist-led dosing and therapeutic monitoring of intravenous vancomycin therapy for UConn Health John Dempsey Hospital inpatients

**5.) COST-JUSTIFICATION, INCLUSION, AND EXCLUSION CRITERIA:**

**5.1.) Cost of Services Provided under the Vancomycin Collaborative Practice Agreement:**

* The services provided by UConn Health John Dempsey Hospital Pharmacists under the Vancomycin Collaborative Practice Agreement will be provided at no additional charge to the patients.  The service will be justified based on cost avoidance through such measurable outcomes as:

(1) reduced risks of vancomycin toxicities,

(2) reduced numbers of blood draws for determinations of vancomycin serum concentrations,

(3) quicker therapeutic dosage standardization, and/or

(4) reduced duration of hospitalization

**5.2.) Inclusion Criteria:**

* All adult inpatients > 16 years old who are admitted to UConn Health John Dempsey Hospital adult inpatient treatment units who are prescribed IV vancomycin therapy

**5.3.) Exclusion Criteria:**

* All patients under the age of 16 years
* All patients receiving vancomycin for surgical prophylaxis or patients prescribed oral vancomycin for the treatment of *Clostridioides difficile* infections.

**6.) PROCEDURES FOR THE VANCOMYCIN COLLABORATIVE PRACTICE (VCP) AGREEMENT**:

**6.1.)  Patients Initiated on IV Vancomycin Therapy dosed by pharmacy:**

6.1.1.) To initiate the protocol for inpatients, the patient’s appropriately-credentialed practitioner will select the “**Vancomycin Dosed per Collaborative Practice Protocol**” order in the Electronic Medical Record (EMR) system.

6.1.1.1) Selection of Initial Weight-Based Vancomycin **Loading Dose**: As part of the “**Vancomycin Dosed per Collaborative Practice Protocol**” order in the EMR system, the practitioner will select an initial weight-based loading dose of **25 mg/kg (based on total body weight).** The dose will be rounded to the nearest 250 milligram increment automatically via the EMR system, and **will not exceed 3000 milligrams**.

6.1.1.2.) Selection of the Indication for Use and the target therapeutic range:

The provider will indicate the suspected/documented indication for the vancomycin in the order. An AUC/MIC target of 400-600 mg-h/L will be used by the Pharmacist to develop the initial vancomycin dosing regimen for **all** patients.

6.2..) Pharmacist’s Responsibilities for “**Vancomycin Dosed per Collaborative Practice Protocol**”:

6.2..1.) Collection and Documentation of Baseline Patient Data:

Pharmacists will review the following patient data from the patient’s EMR. These data are necessary to develop an optimized initial (empiric) vancomycin dosing regimen:

* Patient age and gender
* Allergy history
* Current / most recent height, total body weight, and Body Mass Index (BMI):
  + - * **Note**: Review to obtain current weight; contact the nurse and/or prescriber to double-check and verify any unusual parameters [e.g., height <60 inches, Actual body weight < 40 kg or >150 kg] and/or to evaluate for significant changes in any of the above parameters from previous archived data)
* Current and historical serum creatinine (Scr) values
  + - * **Note**: Pharmacists should always attempt to assess for the presence of acute, chronic, and/or acute-on-chronic renal insufficiency)
* Documented/Suspected infectious diagnosis or the apparent indication for use of vancomycin therapy
* Initial dose(s) of vancomycin administered and the date(s)/time(s) that it was administered (as applicable - if vancomycin was started before the order for VCP dosing)

Pharmacists will contact the patient’s nurse and/or caregivers and/or other valid resources to clarify any unusual data or to determine patient data which is not documented in the EMR.

6.2..2.) Identification of Patients with “**Special Dosing and/or Therapeutic Monitoring Considerations**”:

Pharmacists will review relevant patient data to determine if any of the following conditions are present which would warrant the use of “**Special Vancomycin Dosing and/or Therapeutic Monitoring Considerations**”:

* Patient admitted to the ICU with critical illness
* Patient receiving Chronic or Acute Hemodialysis (HD)
* Patient receiving other Continuous Renal Replacement Therapy (CRRT)
* Patient with Significant Obesity, defined as one or more of the following:
  + - * BMI >40), and/or Actual Body Weight > 40% of Ideal Body Weight
* Patient with Serum Creatinine < 0.8 mg/dL and one or more of the following:
  + - * Age >80 years,
      * low serum total protein, albumin, prealbumin (and/or other valid markers of nutritional status and/or muscle mass),
      * acute/chronic hepatic dysfunction
* Patient with significant acute alterations/changes in renal function
* Patient with documented positive blood cultures with gram-positive cocci
* Patient close to hospital discharge with need for continuation of vancomycin as an outpatient (with need for either the start of vancomycin therapy prior to discharge or a change in the current vancomycin regimen based on a serum trough concentration)

Considerations, recommendations, and detailed guidance for vancomycin dosage and administration intervals and therapeutic monitoring for patients with these “Special Dosing and/or Therapeutic Monitoring Considerations” can be found in the subsections of **Section 6.3** (**Special Vancomycin Dosing and/or Therapeutic Monitoring Considerations**)

6.2..3.) Determination of **Initial Vancomycin Maintenance Regimen** Dose and Administration Interval for Patients with NO “Special Dosing and/or Therapeutic Monitoring Considerations”:

Each patient’s initial vancomycin maintenance regimen dose and administration interval will be determined by the Pharmacist with the following considerations as follows:

* A maximum initial **single administered dose** of **2000 milligrams per dose**
* A maximum initial **total daily dose** of **4000 milligrams per day**
* An initial estimated therapeutic AUC range of 400-600 mg-h/L will be used for ALL PATIENTS
* The Clincalc.com “*Beta-Version Vancomycin calculator*” (<https://clincalc.com/Vancomycin/Beta.aspx>) will be utilized using the “Bayesian Modeling Population Estimates” and other relevant patient-specific parameters as defined on the UConn Health John Dempsey Hospital Pharmacy Department website (https://health.uconn.edu/pharmacy/) to construct the initial regimen (see **APPENDIX 1**).
* The values for both the dose and the administration interval that are obtained from the *Clincalc.com Vancomycin Beta-version Calculator* should be rounded as follows:
  + - * **Vancomycin Dose**:
        + 250 milligram increments from 500 milligrams to 2000 milligrams
      * **Administration Interval:**
        + Every 8, 12, 24, 48, or 72 hours (based on patient pharmacokinetic factors). To minimize negative effects on transition of care, intervals of 18 or 36 hours may only be considered for use **after a failure to reach therapeutic concentrations twice with the recommended intervals**. It must be specifically documented by the pharmacist that preferred intervals could not be used due to patient-specific considerations. Additionally, if a patient was admitted on a stable 18 or 36 hour regimen, they may remain on the regimen as appropriate.

Additional considerations, recommendations, and detailed guidance for vancomycin dosage and administration interval for patients with “Special Dosing and/or Monitoring Considerations” can be found in the respective subsections of **Section 6.3** (**Special Vancomycin Dosing and/or Monitoring Considerations**)

6.2..4.) Determination of Infusion Times for Vancomycin Doses:

Infusion-related events (i.e., “Acute Histamine Release Syndrome”) are a product of both the concentration of the vancomycin intravenous solution and the infusion rate. In an effort to reduce the risks of infusion-related events, the following infusion rate guidelines were previously developed and approved as UConn Health John Dempsey Hospital policy.

* Doses of 500-1000 mg: **Infuse over 1 hour**
* Doses of 1250 mg-1750 mg: **Infuse over 2 hours**
* Doses ≥ 2000 mg: **Infuse over 2.5 hours**

Infusion reactions may still occur even with these longer infusion times and should be managed on an individual case-by-case basis if they occur. Strategies to mitigate the infusion reaction include:

(a) further prolongation of the infusion time,

(b) pre-medication with antihistamines such as diphenhydramine, famotidine, and/or

(c) pre-medication with corticosteroids such as hydrocortisone or methylprednisolone.

6.2..5.) Initiation of the Orders for the Collaborative Practice Protocol-Determined Vancomycin Regimen:

* Within **2 hours** (within **1 hour** for **patients in the ICU/ED**) of the “***Vancomycin Dosed per Collaborative Practice Protocol***” order, the Pharmacist will determine and verify the **initial loading dose**. An active order for this regimen with subsequent maintenance dosing and administration interval should be completed by the pharmacist within 6 hours of the original consult order.

6.2..6.) Scheduling and Ordering of Initial Vancomycin Serum Concentrations:

* All patients who are prescribed IV vancomycin for the treatment of any infection will have blood drawn for determination and evaluation of serum vancomycin concentrations as follows:
* **For patients with (1) BMI <40, (2) No evidence of positive blood cultures for gram-positive cocci, and/or (3) non-ICU admitted patients who have no substantial acute alterations in renal function** (determined via: assessment of daily trends in serum creatinine during hospitalization, and/or comparison of initial serum creatinine on admission to stable outpatient values) **AND** who appear to be **hemodynamically stable** (determined via such clinical factors as: assessment of blood pressures, absence of orders for intravenous vasopressor agents):
* Serum peak and trough blood draws for determination of vancomycin concentrations should **ONLY** be ordered/assessed if the **therapy continues for at least 3 days (72 hours).**
* The Pharmacist will first review ordered laboratory tests for any pre-existing orders for vancomycin trough concentrations:
  + If there are no pre-existing orders for vancomycin concentrations, then the Pharmacist will schedule peak and trough blood draws such that the date and time of the blood draw occurs: (1) no earlier than day #3 (72 hours) of therapy, and (2) the **trough** blood draw will be scheduled to occur within one hour prior to the start of an infusion of a dose, and (3) the **peak** blood draw will be scheduled to occur 1-2 hours after the end of that same dose infusion.
  + If pre-existing orders for vancomycin serum concentrations are present, then the Pharmacist will reschedule the date(s) and/or time(s) of the blood draws as appropriate.
* The Pharmacist will also document this information in the pharmacy note.
* Serum vancomycin peak, trough, and/or random serum concentrations can be ordered and assessed **PRIOR TO 72 hours of therapy ONLY in the following clinical situations:**
* **Critically-Ill patients (ICU patients)** with or without hemodynamic instability
* Patients with a **BMI > 40**
* Patients with documented positive blood cultures for gram-positive cocci and/or patients with suspected pneumonia and a positive MRSA PCR nasal swab
* Any patients **with substantial acute alterations in renal function** (as assessed via: daily trends in Scr during hospitalization, comparison of initial Scr upon admission to the hospital to stable outpatient values, significant reductions in urine output, etc.)
* Patients on **Hemodialysis or other Continuous Renal Replacement** Therapies
* Patients with **anticipated hospital discharge prior to 72 hours of therapy**

6.2..7.) Documentation of the Collaborative Practice Protocol-Determined Initial Vancomycin Regimen in the Patient Medical Record:

* Per Connecticut State Law, “*All activities performed by the Pharmacist in conjunction with the protocol shall be documented in the patient’s medical record*.”
* At the conclusion of the initial dosage regimen development process, the Pharmacist will complete the “**Pharmacy Note: Initial IV Vancomycin Dosing per Collaborative Practice Protocol”** (see **APPENDIX 2**) and post it to the patient’s EMR.
* Whenever possible, the Pharmacist also should make an effort to provide a verbal summary of the key information related to the Vancomycin therapy to the patient’s medical and nursing provider(s).

6.2..8.) Daily Follow-up of Key Clinical Parameters for Patients on Vancomycin Therapy:

* **EACH DAY**, Pharmacists will review and analyze the following clinical data for all patients on Vancomycin therapy. Relevant notations can be made in the “Handoff – Pharmacy To Do” section of the EMR to facilitate continuity of care amongst Pharmacists:
* Renal function trends (via Scr):
  + - * + If a Pharmacist notes that there has not been an assessment of serum creatinine/blood urea nitrogen for >48 hours, the Pharmacist can enter an order into the EMR to schedule a blood draw for assessment of serum creatinine/blood urea nitrogen.
        + A Pharmacist may order a serum creatinine sooner than 48 hours if a patient meets criteria for special dosing considerations (e.g. concomitant use of nephrotoxic medications (e.g. Zosyn®) or medications that may lead to increase in incidence of AKI).
* Patients Requiring More Frequent Trough Monitoring Include:
  + Obesity (BMI>40)
  + Pre-existing renal dysfunction and/or acutely changing renal function
  + Receiving concurrent therapy with one or more nephrotoxins (e.g. piperacillin/tazobactam, amphotericin B, aminoglycosides, high-osmolar intravenous contrast dye, loop diuretics, vasopressors, and ACE inhibitors).
* Receipt of other well-known nephrotoxic medications (most commonly: amphotericin B, aminoglycoside antibiotics, intravenous contrast dyes used for radiologic procedures)
* Results of culture and susceptibility results
* Significant deviations in administration of any Vancomycin doses (e.g., missed doses, doses administered at wrong times (this will depend on the dosing interval--some examples: (i) a dose administered 2 hours late for a patient on an every 8 hour schedule, (ii) a dose administered 6 hours late for a patient on an every 24 hour schedule)
* Results and interpretations of any serum vancomycin concentrations
* Any time doses or administration intervals are changed, the Pharmacist **MUST** complete a “**Pharmacy Follow-Up Progress Note: IV Vancomycin Therapy per Collaborative Practice Protocol**” (**APPENDIX 3**) and post this note in the patient’s EMR
* Any time any patient finding is noted that could significantly impact the current vancomycin regimen, the Pharmacist **MUST** fill out a “**Pharmacy Follow-Up Progress Note: IV Vancomycin Therapy per Collaborative Practice Protocol**” (**APPENDIX 3**) and post this note to the patient EMR. This should occur even if it is decided that there does not need to be an immediate change in the patient’s current vancomycin regimen.
* Whenever possible, the Pharmacist also should also make an effort to provide a verbal summary of the key information related to the Vancomycin therapy to the patient’s medical and nursing provider(s)
* Pharmacists will directly notify practitioner verbally if:
  + Significant decline in renal function (e.g. doubling in SCr)
  + Supratherapeutic Vancomycin Level (e.g. trough or random)
    - Pharmacists can enter an order in the EMR for a MRSA PCR nasal swab in a patient who has a probable or definitive diagnosis of pneumonia. This can be determined either through: (a) review of the type of infection selected for the order for vancomycin, (b) review of the progress notes in the patient’s EMR, or (c) a verbal discussion with the patient’s caregivers
      * If a patient with documented/suspected pneumonia has a documented negative MRSA PCR nasal swab test, the Pharmacist can discontinue the order for IV vancomycin. Prior to discontinuing the order, the Pharmacist should contact the primary care team to alert them of the order discontinuation. The Pharmacist should also fill out a “**Pharmacy Follow-Up Progress Note: IV Vancomycin Therapy per Collaborative Practice Protocol**” (**APPENDIX 3**) and post this note to the patient EMR. The note should specifically document that IV Vancomycin therapy is being discontinued due to a negative MRSA PCR nasal swab test result.

6.2..9.) Assessment of Serum Vancomycin Concentrations:

* When scheduled vancomycin serum peak, trough, and/or random concentration values are reported, the Pharmacist will first assess their validity for use as an indicator of the appropriateness of the patient’s current vancomycin dosing regimen by performing the following steps:

6.2..9.1) Determine whether the peak and/or trough were appropriately timed in relation to the administered doses. For the trough, this is best accomplished by assessing both (i) the time that elapsed between the administration of the previous dose and the time of the blood draw, as well as (ii) the time that elapsed between the time of the blood draw and the administration of the next dose. For the peak concentration, the blood draw ideally should occur between 1-2 hours after the END of the infusion (but between 1-3 hours is acceptable and can be used for pharmacokinetic determinations)

6.2..9.2) Determine whether the peak, trough, and/or random serum concentration should be considered “**steady-state**” versus “**non-steady-state**”. A steady state trough is defined as:

(a) blood drawn at least 4 estimated half-lives after administration of the first dose of vancomycin, AND

(b) all doses administered prior to the blood draw were identical (with the exception of the loading dose), AND

(c) all administration intervals remained reasonably consistent prior to the blood draw, AND

(d) all clinical data indicates renal function and hemodynamic function have remained reasonably stable.

6.2..9.3.) If any deviations are discovered as defined above in Sections 6.2..9.1 & 6.2..9.2, the Pharmacist **will still make every possible effort to use the serum concentrations** to assess the patient’s dosing regimen for appropriateness using basic pharmacokinetic principles as defined and outlined on the UConn Health John Dempsey Hospital Pharmacy Department website (https://health.uconn.edu/pharmacy/) (**APPENDIX 1**) as well as with the use of the Vancomycin dosing calculator on Clincalc.com. The re-draw of serum concentrations should be avoided whenever possible.

An Illustrative Case Example:

*A patient is started on Vancomycin 1000 milligrams IV every 12 hours. His half-life was estimated to be 6 hours. A “trough” concentration is obtained at steady-state and is reported in system as 22 mg/L (at face-value, considered “supratherapeutic”). HOWEVER, upon further investigation, the Pharmacist notes that the patient’s previous dose administration was delayed for 3 hours...so the actual elapsed interval time was* ***not 12 hours****, but actually* ***only 9 hours****. For a patient with an estimated half life of 6 hours, the Pharmacist could approximate (using basic pharmacokinetic equations and the online dosing calculator) that the “true” trough (i.e., the concentration* ***3 hours*** *after the reported concentration of 22 mg/L) would be* ***~20-30% lower that the reported value*** *(so,* ***~16-18 mg/L****, which would be considered “****therapeutic****”). Thus, the regimen should actually continue as originally devised (assuming that the assessment of the patient’s AUC/MIC also determines that it is within the 400-600 mg-h/L therapeutic range). No repeat vancomycin trough analysis should occur.*

6.2.9.4.) When the serum peak, trough, and/or random concentrations are deemed to be **properly drawn** with respect to both general timing and/or pharmacokinetic steady state, then the Pharmacist will take the following approach for vancomycin regimen adjustments:

* **ALL** regimens resulting in a **trough concentration > 20 mg/L** will be considered as **supratherapeutic** regimen and will require adjustment to achieve a **trough < 20 mg/L** and a calculated/estimated **AUC of 400-600 mg-h/L**
* For regimens with a **trough concentration <20 mg/L**, the patient-specific information and the data on the peak, trough, and/or random concentrations should be entered into the dosing calculator (<https://clincalc.com/Vancomycin/Beta.aspx>). A dosing regimen should be selected to assure that the **AUC is within the 400-600 mg-h/L range**. It is important to note that there may be patients whose regimens result in a “therapeutic” AUC but whose troughs may be below 10 mg/L. This is still considered an acceptable dosing regimen.
* **Considerations for Trough concentration > 30 mg/L:**

* The Pharmacist will view this unexpectedly high trough concentration result as an indicator for one or more of the following clinical events:

(i) individual patient vancomycin pharmacokinetics that vary substantially from the “population average” that was used for initial regimen design,

(ii) an early sentinel sign of renal dysfunction that has not yet manifested via an increase in Scr (i.e., it is common for Scr changes to lag behind actual changes in renal function by 2 or more days).,

(iii) a potential undocumented error in either the administration of the IV vancomycin or the timing of the blood draw, and/or

(iv) a potential error in the process of obtaining the blood sample (e.g., blood drawn through the IV line that Vancomycin was administered through without proper flushing of the IV line prior to the blood draw).

* If the unexpectedly high trough concentration is determined to be “real” and the next scheduled dose **has NOT been given**, the Pharmacist will discontinue the active order for Vancomycin and will consider scheduling a follow up “random” Vancomycin serum concentration. Since this clinical scenario will occur most commonly in patients with renal impairment, the serum vancomycin half-life can be expected to exceed 12 hours. Due to this factor, a follow up “random” blood draw **should not be ordered** **any sooner than 24 hours** after the previously-obtained blood draw. Subsequent “random” blood draws should **NOT** be ordered **any more frequently than** **once daily**.
* Before an active Vancomycin order is discontinued, the Pharmacist **MUST** initiate a discussion with the patient’s provider to determine the continuing need for Vancomycin therapy (to be re-started). If continuing therapy is needed, then the Pharmacist must:
* Document pertinent information in the “Handoff – Pharmacy To Do” section of the EMR as well as the Pharmacy I-Vent section of the EMR

6.2.9.5.) Every time a Vancomycin Serum Concentration result is analyzed (even if no changes in dosage regimen are warranted), the Pharmacist **MUST** fill out a “**Pharmacy Follow-Up Progress Note: IV Vancomycin Therapy per Collaborative Practice Protocol**” (**APPENDIX 3**) and post this into the “Progress Notes” section of the patient’s EMR.

6.2.9.6) Vancomycin Time Out:

-A 72 hour Vancomycin Time Out will require the ordering provider to re-evaluate the appropriateness of continuing vancomycin therapy

-A 7 day time out will require the ordering provider to re-evaluate the appropriateness of continuing vancomycin therapy.

**6.3.) Special Vancomycin Dosing Considerations:**

**6.3.1.) Chronic or Acute Hemodialysis (HD):**

6.3.1.1.) Key Background Information (5-9):

* *Staphylococcus aureus* is one of the most common causes of serious systemic infections in HD patients, so IV vancomycin will be initiated in most HD patients with signs & symptoms that suggest a bacterial infection
* Since vancomycin is primarily eliminated via the kidneys, the terminal elimination half-life in anuric patients is long (100-200 hours) and is a result of a small fraction of non-renal clearance (most likely due to hepatic conjugation)
* On average, the Volume of distribution (Vd) tends to be higher in HD patients (0.7 - 0.9 L/kg) than in non-HD patients, but it is still within the range observed in non-HD patients (0.4-1.0 L/kg)
* The “high-permeability” HD membranes that are currently used remove approximately 30-50% of the circulating intravascular concentration of vancomycin during a typical ~4 hour HD session.
* The amount removed is predominantly influenced by the duration of the HD session (shorter HD sessions (i.e., 1-2 hours) will remove substantially less drug)
* There is a “rebound phase” following a HD session where the intravascular vancomycin concentrations will increase (by approximately 20-30%) when compared to the immediate post-HD concentrations.
* This “rebound phase” is a result of extravascular-intravascular equilibration and usually lasts approximately 3-6 hours

6.3.1.2.) Additional Baseline Patient Data to Collect, Assess, & Document for HD Patients:

* The Pharmacist will review the EMR system for specific details about the patient’s HD schedule (i.e., “One Time” HD session, Scheduled HD sessions (days, times, duration), Combinations of “One Time” and Scheduled HD sessions). If there are no HD Orders in the CPOE system (and the patient is a known HD patient), then the Pharmacist will contact the Hemodialysis Unit to determine the anticipated orders and to alert them of the need for the Nephrology Service to enter HD orders into the EMR system. [???Still applicable with EPIC]
* The Pharmacist will assess the patient for the presence of any residual renal function (which usually will be documented in nephrology/hemodialysis medical records, progress notes, or can be determined via discussions with caregivers)

6.3.1.3.) Development of Initial Vancomycin Dose and Administration Interval for HD patients:

* The <https://clincalc.com/Vancomycin/Beta.aspx> calculator **DOES NOT** need to be utilized for HD patients who need vancomycin therapy
* An initial IV Vancomycin **loading dose** of **25 mg/kg** (Actual Body Weight, **up to a maximum single dose of 3000 milligrams**) should be computed and rounded to the nearest 250 milligram increment
* The first treatment dose of Vancomycin should be administered **as soon as possible** and without regard to the patient’s HD schedule.
* With the exception of the first treatment dose (as described above), **ALL** subsequent doses of vancomycin should be scheduled to be administered on HD days **after the patient’s HD session is complete.**
* The initial planned dosing interval should correlate with the patient’s specific HD schedule (with doses typically scheduled in the late afternoon [after ~3-4pm] after the patient’s HD session is complete)

6.3.1.4.) Scheduling and Ordering of the Initial Vancomycin Serum Concentration for HD patients:

* The use of the 25 mg/kg (actual body weight) loading dose should result in pre-dialysis serum vancomycin concentrations of > 10 mg/L in nearly all HD patients.
* The first blood draw will be scheduled **on the first inpatient HD session day AFTER the loading dose**, and will be scheduled to occur **in the morning prior to the patient’s HD session**
* A ***possible*** exception to this recommendation:
  + - A HD patient who has **confirmed residual renal function** who is scheduled for HD **twice-weekly** (possibly also thrice-weekly) and who has received his/her first dose of vancomycin in the afternoon on a HD session day (i.e., **after** his/her HD is complete).
      * In such a case scenario, the patient’s residual renal function could potentially eliminate enough vancomycin from his/her body such that serum concentrations may decrease to below 10 mg/L well before the next scheduled HD session.
      * In this case scenario, it would be appropriate to assess a “random” serum concentration on a non-HD day to assure that subtherapeutic vancomycin concentrations are not present.
      * **Specific Illustrative Example**: A 100 kg male patient with some residual renal function is scheduled for HD on Monday, Wednesday, and Friday. He is admitted to UConn Health John Dempsey Hospital and receives his first vancomycin dose on Friday at 1800 (after his Friday HD session).
        + Since he has residual renal function, it is quite possible that his serum vancomycin concentrations could decrease to less than 10 mg/L as early as mid-day on Sunday.
        + A serum vancomycin concentration could be scheduled to be evaluated on Sunday to evaluate for this possibility (and to justify administration of an additional dose, if warranted).

6.3.1.5.) Assessment of the Initial Serum Vancomycin Concentration and Determination of the subsequent Vancomycin doses in HD patients:

* The therapeutic range for patients on HD should be a **pre-dialysis serum concentration of 15-20 mg/L**. This will assure an **AUC/MIC of 400-600 mg-h/L** throughout the dosing interval.
* Most patients receiving thrice-weekly HD will need a Vancomycin maintenance dose of **10 mg/kg** (total body weight) administered after the HD session in order to maintain pre-dialysis concentrations between 15-20 mg/L.
* After documentation of proper timing of the blood draw, the pre-HD serum concentration result should be used to determine the amount of the next Vancomycin dose to be administered (after the patient’s HD session) per the following recommendations outlined below:
* Pre-dialysis concentration 5-10 mg/L: Increase next 10 mg/kg maintenance dose by ~50%
* Pre-dialysis concentration 10-14 mg/L: Increase next 10 mg/kg maintenance dose by ~25%
* Pre-dialysis concentration 15-20 mg/L: No change in 10 mg/kg maintenance dose
* Pre-dialysis concentration 21-25 mg/L: Decrease 10 mg/kg maintenance dose by ~25%
* Pre-dialysis concentration 26-30 mg/L: Decrease 10 mg/kg maintenance dose by ~50%
* Pre-dialysis concentration >30 mg/L: Consider holding next dose or decrease 10 mg/kg maintenance by ~75%

**6.3.2.) Patients on Other Continuous Renal Replacement Therapies (CRRT):**

6.3.2.1.) Background (5):

* The most commonly-used CRRTs used in critically-ill patients are continuous venovenous hemofiltration (CVVH), continuous venovenous hemodialysis (CVVHD), and continuous venovenous hemodialfiltration (CVVHDF).
* As a general rule, these CRRTs are much more efficient at removing vancomycin from the bloodstream than traditional intermittent HD, but the elimination is still somewhat slower than that observed for a patient with normal renal function.
* Most patients receiving CVVH will end up needing vancomycin total daily dosage regimens that will be similar or slightly lower to those computed for patients with normal renal function (e.g., 7.5-10 mg/kg every 12 hours).

6.3.2.2.) Development of the Initial Vancomycin Dose and Administration Interval for CRRT patients:

* The Pharmacist will first determine the specific type of CRRT that the patient is receiving (or is expected to receive, if it has not been initiated yet)
* After this determination, he/she will then start the patient on:
  + - A **loading dose** of **25 mg/kg** (maximum 3000 milligrams)
    - A **maintenance dose** of **7.5-10 mg/kg IV every 12 hours**
* Refer to the detailed guidelines for developing dosing regimens for Vancomycin for the specific type of CRRT that the patient is receiving (information found on the *https://health.uconn.edu/pharmacy/* website)

6.3.2.3.) Scheduling and Ordering of the Initial Vancomycin Serum Concentration:

* Since patients on CRRT will be critically ill in the ICU, the pharmacist can order a serum peak and trough for a patient on CRRT as early as the first maintenance dose to quickly determine the appropriateness of the initial regimen.

**6.3.3.) Patients with Significant Obesity (BMI > 40):**

6.3.3.1.) Background (5):

* Many recent publications and systematic observations also done at UConn Health John Dempsey Hospital confirm that, when compared to non-obese patients, patients with significant obesity:

(i) have a lower weight-indexed Volume of Distribution (L/kg) and can have longer-than-predicted vancomycin terminal elimination half-lives,

(ii) are at higher risk for supra-therapeutic serum vancomycin troughs, and

(iii) have a higher risk for vancomycin-associated nephrotoxicity.

6.3.3.2.) Development of the Initial Vancomycin Dose and Administration Interval:

* The Vancomycin **loading dose** will be **25 mg/kg (maximum 3000 milligrams)**
* The initial maintenance dosing regimen will be initially computed using <https://clincalc.com/Vancomycin/Beta.aspx> as detailed in **Section 6.2.3**.

6.3.3.3.) Scheduling and Ordering of the Initial Vancomycin Serum Trough Concentration:

* The Pharmacist should schedule and order the initial vancomycin serum peak and trough analysis as outlined in **Section 6.2.2.6**, with the following modification: The pharmacist should order the initial peak and trough blood draws within the first **24-48 hours** of therapy.

6.3.3.4.) Assessment of the Initial Serum Vancomycin Trough Concentration and determination of the subsequent Vancomycin doses:

* The Pharmacist will assess the initial serum trough concentration and adjust the regimen as needed as outlined in **Section 6.2.9.3**.

**6.3.5.) Patients with Acute Changing Renal Function:**

6.3.5.1.) Background:

* It is important to recognize that the Cockcroft-Gault CLcr is inaccurate and unreliable in patients who have either acute improvement or worsening of renal function.
* It is also difficult to determine when “steady state” will be achieved for the proper assessment of vancomycin serum concentrations (since the clearance of the drug will be varying from day-to-day)

6.3.4.2.) Development of the Initial Vancomycin Dose and Administration Interval:

* When the Vancomycin dosing regimen is computed as described in **Section 6.2.3**, the Pharmacist will consider the following additional measures when developing Vancomycin dosing regimens and when monitoring serum concentrations:
  + If the patient’s renal function is worsening, either (i) decrease the vancomycin dose by ~25%, (ii) extend the administration interval to the next highest clinically-acceptable interval (e.g., from every 12 hours to every 24 hours), or (iii) initiate both a dosage decrease and an interval extension
  + If the patient’s renal function is improving, consider either (i) increase the vancomycin dose by ~25%, (ii) decrease the administration interval to the next lowest clinically-acceptable interval (e.g., from every 12 hours to every 8 hours), or (iii) initiate both a dosage increase and an interval decrease

6.3.3.3.) Scheduling and Ordering of the Initial Vancomycin Serum Trough Concentration:

* In general, the Pharmacist will schedule and order the initial vancomycin serum trough analysis as outlined in **Section 6.2.6**.
* However, it is acceptable for the Pharmacist to schedule and order serum vancomycin concentrations **prior to 72 hours** of therapy (as outlined in Section 6.2.3.) in patients with **large alterations in renal function** (determined by serum creatinine values) as compared to baseline stable values in order to assure the highest chance of therapeutic efficacy and lowest chance of drug toxicity. For example, in a patient with a stable baseline Scr of 1.0 mg/dL, it would be appropriate to schedule and assess serum concentrations before 72 hours of therapy when the admit Scr is 1.5 mg/dL (and is expected to improve or has been documented to improve). Conversely, if that same patient had only a smaller elevation from baseline (e.g., only 1.2 mg/dL), it would be more appropriate to wait to evaluate serum concentrations until after 72 hours of therapy.

6.3.3.4.) Assessment of the Initial Serum Vancomycin Trough Concentration and determination of the subsequent Vancomycin doses:

* The Pharmacist will assess the initial serum trough concentration and adjust the regimen as needed as outlined in Section **6.2.9.3**.
* Recent trends in renal function **MUST** be closely scrutinized to aid in the interpretation of the serum trough concentration.

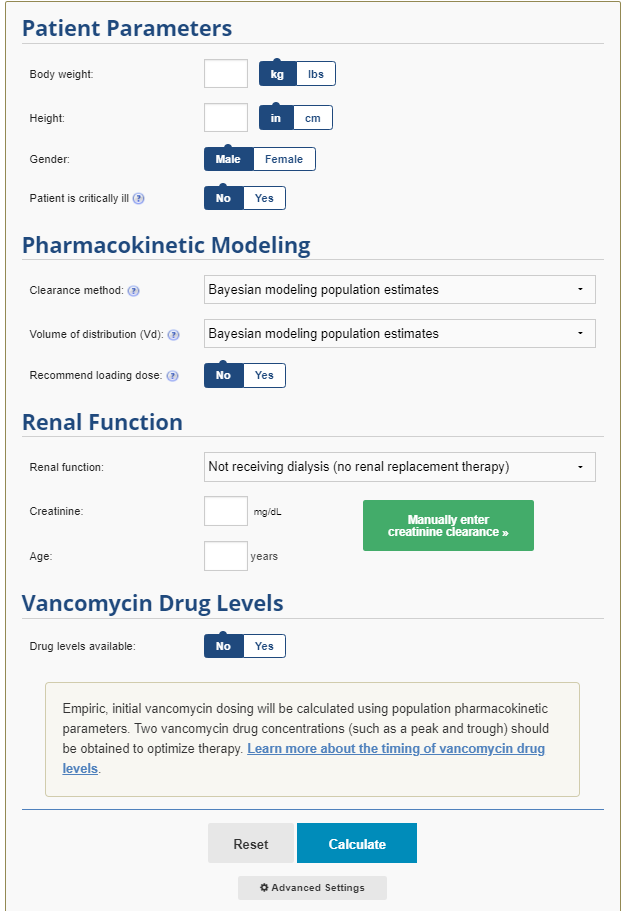
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**Appendix 1 (Part 1 of 2):  Detailed Pharmacokinetic Information on the https://health.uconn.edu/pharmacy/ Website**

**Screenshot of data-entry form for use of the ClinCalc Vancomycin Calculator**

**(**[**https://clincalc.com/Vancomycin/Beta.aspx**](https://clincalc.com/Vancomycin/Beta.aspx)**)**



**Appendix 1 (Part 2 of 2): Detailed Pharmacokinetic Information on the pharmacy.uchc.edu Website**

**Pharmacokinetic Equation & Method to Estimate a Serum Vancomycin Trough Concentration from any given actual Vancomycin Serum Concentration:**

**Equation: Ct1 = Cknown \* e-k\*t1**

**Where:**

**Cknown = Vancomycin Concentration result from the patient**

**Ct1 = Vancomycin Concentration that you want to estimate at a specific time relative to Cknown**

**k = elimination rate constant (estimated from the “Advanced Dosing Calculator” shown above)**

**t1 = the specific time between the Cknown and Ct1**

**Patient Case Example:**

A patient was started on Vancomycin 1000 milligrams IV every 12 hours.  His vancomycin elimination half-life (“t1/2”) and elimination rate constant (“k”) were determined to be 6 hours and 0.116 hours-1 with the “Advanced Pharmacokinetic Dosing Calculator” tool.

A “trough” concentration was obtained at steady-state and was reported in the Netaccess/LCR system as 22 mg/L (“supratherapeutic”).  However, upon further investigation, the Pharmacist notes that the patient’s previous dose administration was delayed for 3 hours...so the actual elapsed interval time was not 12 hours, but 9 hours.  What would you expect this patient’s actual trough to be?

Solution: To estimated the “true” trough serum concentration:

**Ct1 = Cknown \* e-k\*t1**

**Ct1 = 22 mg/L \* e-(0.116) \* (3 h)**

**Ct1 = 22 mg/L \* (0.71)**

**Ct1 = 15.6 mg/L**

**Appendix 2 – VCP Pharmacy Note for EMR – Initial IV Vancomycin Dosing**

UCONN RX VANCOMYCIN DOSING INITIAL NOTE (13932)

**Pharmacy: Initial IV Vancomycin Dosing**

@NAME@ is a @AGE@ @SEX@ who has been initiated on Vancomycin for {UCONN RX VANCOMYCIN THERAPY:25814} therapy for {UCONN RX VANCOMYCIN INDICATIONS:20999}. The target vancomycin trough is {UCONN RX VANCOMYCIN GOAL TROUGH:20998}.

**Height:** @LASTHT(1)@

**Actual Body Weight**: @LASTWT(1)@

**Temperature**: @LASTTEMP(3)@

**BUN:** @LASTLAB(BUN)@

**SCr:** @LASTLAB(CREATININE:3)@

**Estimated CrCl:** @CRCL@

**WBC:** @LASTLAB(WBC:3)@

**Albumin:** @LASTLAB(ALBUMIN)@

**Microbiology**

Cultures Drawn? {YES/NA/NO/\*\*\*:28797}

Culture Results: {CULTURES:23518}

**Special Dosing Considerations:**

{UCONN RX VANCOMYCIN DOSING SPECIAL CONSIDERATIONS: 25812}

**Plan:**

@VANCODOSES@

**Loading Dose:** \*\*\*

**Maintenance Regimen:** Pharmacy will start Vancomycin at a dose of {UCONN RX   VANCOMYCIN DOSES:25809} IV {UCONN RX VANCOMYCIN INTERVALS:25371}

  Pharmacy scheduled {UCONN RX VANCOMYCIN TROUGH RANDOM:30219} on {UCONN RX   TIME; MONTH, DAY, YEAR, TIME:30231}

**Additional Comments**: Pharmacy will continue to monitor daily and if indicated, adjust dose and/or frequency, order lab work as appropriate per the Pharmacy and Therapeutics Committee approved collaborative practice until discontinuation of the medication.

Assessment completed by:

@ME@ @TD@ at @NOW@

Collaborative Practice Agreement found here:

<https://health.uconn.edu/pharmacy/staff-references/vanco-collaborative-practice/>

**Appendix 3 – VCP Pharmacy Note for EMR - Follow-up IV Vancomycin Dosing**

UCONN RX VANCOMYCIN FOLLOW UP DOSING NOTE (14048)

**Pharmacy: Follow-up IV Vancomycin Dosing**

@NAME@ is a @AGE@ @SEX@ who is on Vancomycin for {UCONN RX VANCOMYCIN INDICATIONS:20999}. The target trough is {UCONN RX VANCOMYCIN GOAL TROUGH:20998}.

**Temperature**: @LASTTEMP(3)@

**BUN:** @LASTLAB(BUN:3)@

**SCr:** @LASTLAB(CREATININE:3)@

**Estimated CrCl:** @CRCL@

**WBC:** @LASTLAB(WBC:3)@

**Culture Results**: {CULTURES:23518}

**Current Vancomycin Dosing:** @VANCODOSES@

**Most Recent Vancomycin Level**: @LASTLAB(VANCORANDOM:1)@ @LASTLAB(VANCORANDOM:1)@

**Assessment:**

Temperature is {IMPROVING/STABLE/WORSENING:21462}, WBC is {INCREASING/DECREASING/STABLE:15050}, Scr is {INCREASING/DECREASING/STABLE:15050}, CrCl is {INCREASING/DECREASING/STABLE:15050}, Vancomycin level is {UCONN RX VANCOMYCIN LEVEL CLASSIFICATION:25826}.

**Plan:**

{UCONN RX VANCOMYCIN CONTINUE/CHANGE:26796}

Vancomycin {UCONN RX VANCOMYCIN DOSES: 25809} IV {UCONN RX VANCOMYCIN INTERVALS: 25371}

Pharmacy scheduled {UCONN RX VANCOMYCIN TROUGH RANDOM:30219} on {UCONN RX   TIME; MONTH, DAY, YEAR, TIME:30231}

**Additional Comments**: Pharmacy will continue to monitor daily and if indicated, adjust dose and/or frequency, order lab work as appropriate per the Pharmacy and Therapeutics Committee approved collaborative practice until discontinuation of the medication.

Assessment completed by:

@ME@ @TD@ at @NOW@

Collaborative Practice Agreement found here:

<https://health.uconn.edu/pharmacy/staff-references/vanco-collaborative-practice/>

Approved by the UCHC Pharmacy & Therapeutics Committee on \_\_**12/3/2014**\_\_\_\_\_\_. This service constitutes agreement by the provider with this collaborative practice agreement and satisfies all state legal requirements of a pharmacist collaborative practice agreement.  Under Connecticut State law and CMS requirement the collaborative practice agreement and referral must be renewed yearly by the Pharmacy and Therapeutics Committee by signing a new agreement.

Medical Director Signature:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

PCP/ReferringLIP\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date:\_\_\_\_\_\_\_\_