PARKLAND
LEADERSHIP & ORGANIZATIONAL DEVELOPMENT
DEPARTMENT OF NURSING EDUCATION

CONTINUOUS RENAL REPLACEMENT THERAPY (CRRT)

PURPOSE: To therapeutically intervene in the balance of fluid and/or electrolytes and facilitate removal of excess serum solute/waste in critically ill patients with renal impairment, with an overall goal to attain both metabolic and hemodynamic homeostasis.

INDICATIONS: Alternative treatment for renal failure in acutely ill & hemodynamically unstable patients in the ICU setting, volume overload, acid-base imbalances, uremic syndromes & drug/toxin overdose.

POTENTIAL COMPLICATIONS:
With Venovenous Access Insertion: Infection, bleeding and thrombophlebitis at the site of insertion, dysrhythmias, pneumothorax, hemothorax or hydrothorax
With CRRT: Hemodynamic instability, metabolic derangements, infection, air emboli.

PROCEDURE:
PUMP SET-UP and PREPARING THE VENOVENOUS ACCESS:

1. Get equipment and ordered fluids
   a. Ensure the weights for calibration are in place on the stand.
   b. Ensure the pump is at room temperature
   c. Review the orders and notify pharmacy
   d. Ensure ordered fluids available in Pyxis
2. General tips
   a. Do not skip ahead; set up as the pump prompts.
   b. The pump **does not have battery back-up**, and must remain plugged in
   c**. Always plug into red outlet.**
3. Turn machine on and select "New Patient"
4. **Set excess fluid gain/loss limits per Nephrologists' order (130cc-400cc)**
5. Load CRRT Set as instructed on the screen. **No fluid can be on the scales at this time.**
6. Prepare the lines and solutions as directed by the CRRT on-screen display.
7. Prime with ordered solutions.
8. During this priming, gather equipment for venous access:
   a. Mask, hat, sterile gloves, sterile towels, sterile gauze, chlorhexadine, IV tubing and 1000cc NS & syringes
9. Following the prime and "Self-Test", use "Manual Prime" to clear any air.
   a. Remember, selecting "Reprime," starts the entire prime process again and must use additional 1000cc of NS
   b. Also verify the computer sequences are correct as instructed on the screen. If not, trouble shoot per machine direction the machine is sent to Biomedical Engineering.1
10. Set Flow Rates as ordered & remember:
    a**. Always choose CVVHDF therapy mode**.
    b. The **Ultra filtration rate should not be > 20% of the blood flow rate**
    c. A continuous rate for Heparin infusion **and** the one-time loading bolus dose **cannot be programmed at the time of set-up**; initially set the ordered continuous rate.
9. With blue and red lines clamped, prepare access.
   a. Don mask, hat, and sterile gloves.
   b. Create sterile field
   c. Connect a 5-ml syringe to each port.
   d. Unclamp, aspirate back 5-ml of blood for waste, and reclamp each port.

e. If serum labs are ordered, connect the 10-ml syringe and withdraw blood sample, and reclamp the port.

f. Proceed with connection to CRRT set.

10. Connect the access line (red) to access port, and connect return line (blue) to the return port. Then unclamp both lines and both ports. **The pump must be attached to the patient within 30 minutes of priming.** I unable to initiate within the first 30min. reprime with 1000cc of NS
11. Press "Start" to initiate therapy.
12. **If a Heparin bolus is ordered, return to the "Set Flow Rates" screen at this point and program the pump for a one-time, immediate bolus as ordered**.
13. Make note of initial pressures from each pressure pod.

MONITORING THERAPY:

1. Hourly:
   a. Record the volumes from "Treatment History".
   b. Record and note the trend of the access, return, effluent, and filter pressures.
   c. Verify all connections, assess the patient's access site and distal extremity, and check the bloodlines and filter for clots.
   d. Clear all IV infusion pumps (except those used for controlled substances, which are cleared per procedure). Add all non-CRRT intake volumes together to calculate non-CRRT hourly intake. Then total non-CRRT output .Calculate non-CRRT I & O balance (non-CRRT net balance)
   e. Using the amount of Ultrafiltration, the CRRT "output", calculate the patient's total or net I & O balance that hour. Determine if the hourly goal established by Nephrology has been met.
   f. Set Fluid removal rate for the next hour.
      1. Remember that the CRRT machine will bring it's own I & O balance to "0" meaning that the machine will hourly remove the amounts of fluid used from the dialysate and replacement fluids. However, the CRRT machine cannot track any I & O outside the system (e.g. IV infusions as well as Citrate infusion)
      2. If the order is for a desired Net Fluid Balance, titrate the Fluid Removal Rate based on the Net I & O *(*where: *CRRT + Non-CRRT = Net)*, all intake must be removed as well as the ordered goal. For example, order is for a Net –100 ml/hr. If all continuous gtts added together total 200 ml, the pump must be set to remove 300 ml/hr to attain an I & O balance of –100 ml. (Also attempt to include previous hour goal deficits.)
      3. The Nephrologists' may also order specific fluid removal settings:
         a. "Set the rate at '0'"—meaning no fluid is being removed; this patient will likely have a Net + I & O balance every hour because we are not even removing the fluid he is getting via gtts.
         b. "Set the Fluid Removal Rate hourly as the ICU Flowsheet intake from last hour + 100 ml"
      4. To verify if a treatment (i.e., heparin bolus, etc.) has been done through the CRRT machine, select "Treatment History" and "Events." Scroll through the list to find your information.

ENDING TREATMENT:

1. It is ideal to return the blood whenever possible. Otherwise you have an estimated blood loss of ~100 ml.
2. **Never Return Blood with:**
   a. Suspected Anaphylactic Reaction
   b. Blood Leak Detected
   c. Clotted Filter or visible clots in the blood lines

3. Be certain that all supplies to access the site are ready prior to stopping the pump.
    a. For the Access Site: Mask, Hat, Sterile gloves, Heparin 5000u/ml, 3-ml syringe x 3-4, Sterile needles x2-4, Sterile 10 ml syringe X 2, NS for flushing, Sterile gauze, Chorhexadine, leurlock caps X 2.
    b. For Returning Blood: 250-500ml bag of NS, attached to the access via a 4-way stopcock and secondary tubing which up to this point was used for flushing.
4. Pour chlorhexadine on the sterile gauze. Prepare the saline bag and stopcock. Set up sterile field, dropping on it all syringes & the infusion plugs.
5. Don sterile gloves and prepare syringes. With assistance, fill a 2-3-ml syringes with Heparin 5000units/1cc in the amount of heparin needed for each lumen (as indicated on the catheter). With assistance, fill the two 10-ml syringes with NS.
6. Using the chlorhexadine-soaked gauze, clean around the connections between the lines and the ports of the venous access.
7. Have a non-sterile assistant stop the pump, selecting one of the options (i.e., "End Treatment," "Temporary Disconnect," etc.).
8. Clamp the access line and the access port of the catheter. Disconnect the line from the port and attach a 10-ml NS syringe to the port; unclamp it, flush, and reclamp it. If returning blood, attach the access line to the NS bag. Have the non-sterile assistant unclamp the access line and the NS tubing, and then press and hold the "Start Return" on the screen. The machine draws the NS through the access line and through the system, returning via the return line.
9. When completed, clamp the return line and the return access port, and disconnect. Attach the remaining 10-ml NS syringe, unclamp the port, flush, and reclamp. Detach the NS syringes and attach the 3-ml syringes with the indicated amount of heparin to each port; unclamp, instill the heparin, and reclamp. Detach the syringes and apply the leurlock infusion caps.
10. Clamp all lines on the CRRT set. Then press "Unload." Obtain final treatment information from the "Treatment History" screen.
11. **If a power failure occurs, and the choice is to manually return the blood**:
    a. Follow the previously described preparation.
    b. The nurse will **manually turn the blood pump counterclockwise**. This motion will draw the NS through the system. Handle the access in the same manner described above when disconnecting.

POINTS TO REMEMBER:

1. Blood and dialysate are not in direct contact with one another.
2. The CRRT Set also contains 4 pressure pods. These pods are calibrated by the machine during the initial priming and must not be dislodged or removed while therapy is in progress. If this occurs, the pod's internal diaphragm needs to be realigned via the **"Diaphragm Reposition" procedure** as delineated in the Operator's Manual.
3. The aspiration ports should never be accessed with a needle larger than 20 g.
4. **SAFETY**: The Effluent line passed through the blood leak detector (BLD), which uses a sensor to detect the presence of blood in the effluent. There should not be blood in the effluent, because effluent comes from the dialysate side of the SEMI-PERMEABLE MEMBRANE, NOT the blood side; if actual blood is detected in the effluent, it is suspected that the filter is not intact.
5. **SAFETY**: The Return line passes through an Air detector, and finally through a Return line clamp. This ensures that the blood is safe to return to the patient through the return port of the access.

6. Excess fluid gain/loss limit per Nephrologists' order, 130-400cc. When this limit is reached The machine will alarm "Excess fluid gain/loss limit reached", the blood pump will continue but the therapies will stop. At this point you must take the patient off the Prisma machine and restart using a new filter.

SOLUTIONS/FLUIDS USED:

1. Replacement Solution:
   a. Using a Pre-dilution set, the Replacement Solution enters the blood path just prior to the blood entering the dialyzer/filter
   b. Typical Replacement Solution: NS with or without additives
   c. Addition of Pre-dilution Replacement Solution will increase hydrostatic pressure along the dialyzer promoting convective solute clearance.
2. Dialysate Solution:
   a. Follow MD orders
   b. Several concentrations of Prismasate are available
   c. The dialysate is pumped along one side of the SEMI-PERMEABLE MEMBRANE and creates a concentration gradient for particles in the blood stream to cross (potassium).
3. Anticoagulation:
   a. Citrate (Anticoagulant Citrate Dextrose, or ACD)
      1. Anticoagulant effect by binding Ca^{++}
      2. Therefore, must administer $CaCl_2$ infusion separately through a central line to prevent systemic hypocalcemia (ionized)
      3. The citrate is administered into the circuit via a separate IV pump.
      4. Therapeutic effect monitored via serum ionized calcium levels. Typical rate ~ 150 cc/hr.
   b. Heparin
      1. **Administered via a "built-in" syringe pump (20,0000u / 20cc); syringe pump will only accurately handle a 20 ml syringe.**
      2. **Even if citrate is used, the PRISMA syringe pump should be loaded with a 20 ml syringe with NS in it, and clamped after the priming mode is completed.**

DEFINITIONS:

1. Filtration: Movement of fluid through a filter as the result of mechanical pressure.
2. Hemofiltration Process by which plasma fluid with solution is removed from the blood by circulating the blood across a SEMI-PERMEABLE MEMBRANE by means of ultrafiltration.
3. Ultrafiltration: Additional pressure forces extra fluid through the membrane, pulling fluid from the patient's blood without cleansing impurities.
4. Convection: Movement of solute, along with solvent, secondary to a pressure gradient.
5. Diffusion: Particles cross a semi-permeable membrane from an area of greater concentration to an area of lesser concentration.

PRISMA THERAPY OPTIONS: Blood Flow Rate for all therapies is 10 - 180 ml/min

1. Slow Continuous Ultrafiltration (SCUF)
   a. **Removes** large amounts of fluid.
   b. No replacement or dialysate fluids used.
   c. Maximum Patient Fluid Removal Rate is 2000 ml/hr
2. Continuous Veno-Venous Hemofiltration (CVVH)
   a. The pump using hydrostatic pressure drives solvent through the SEMI-PERMEABLE MEMBRANE.
   b. Removal of midsize particles.
   c. Can provide patient fluid removal if desired.

d. Replacement fluid required. Flow Rate: 100 - 4500 ml/hr.
e. Maximum Patient Fluid Removal Rate is 1000 ml/hr.
f. No dialysate used

3. Continuous Veno-Venous Hemodialysis (CVVHD)
   a. Provides solute removal primarily via diffusion.
   b. Removal of smaller particles such as urea.
   c. Dialysate Solution: typical flow rate of 50 – 2500 ml/hr.
   d. Solute removal is directly proportional to dialysate flow rate.
   e. Maximum Patient Fluid Removal Rate is 1000 ml/hr
   f. No Replacement Solution used.
4. Continuous Veno-Venous Hemodiafiltration (CVVHDF)
   a. Provides solute removal through the combination of diffusion and convection
   b. Removal of small and midsize particles.
   c. Provides patient fluid removal if desired.
   d. Replacement fluid required; Flow rate: 100 - 2000 ml/hr.
   e. Dialysate is required; Flow rate: 50 - 2500 ml/hr.
   f. Maximum Patient Fluid Removal Rate is 1000 ml/hr.

TROUBLE-SHOOTING:

1. WARNING ALARMS (Red light) Note: For safety, all warning alarms cause the blood pump to stop and the return line clamp to engage, preventing the return of blood to the patient.
   a. **Air In Blood** indicates the air detector on the return line has sensed air in the blood line.
      1. Identify the area of air in the line, usually in the return line prior to the air detector.
      2. Isolate that area by placing a dialysis clamp on the line just prior to the aspiration port on the return line.
      3. **Using no greater than a 20 g needle on a syringe**, prepare and access the return line aspiration port and aspirate the air back into the syringe. Note the increasingly negative pressure sensed by the return pressure pod.
      4. Withdraw the needle from the aspiration port while still applying traction on the syringe plunger.
      5. Release the Return line clamp and note the backflow of blood into the space in the tubing previously occupied by the air.
      6. Repeat this process until the air is no longer seen. Then remove the clamp from above the aspiration port, and press "Continue."
   b. Filter Has Clotted
      1. Do not return blood. Discontinue filter and restart the system.
   c. Blood **Leak Detected**
      1. Blood has been detected in the effluent, indicating a communication between the effluent and the blood line, likely due to **damage to the semi-permeable membrane**.
      2. Do not return blood. Note the color of effluent, and review any changes to the patient's treatment regimen. Discontinue filter and restart the system.
2. CAUTION: (Yellow light) **Blood** pump continues to circulate. The pump related to the alarm is temporarily stopped.
   a. Return **Disconnection Cannot Be Detected**
      1. The CRRT machine automatically sets **alarms 50 above and below** what it senses to be the average pressures. However, the alarm limits cannot cross over "0" from negative to positive or vice versa. Therefore, if a pressure is sensed to be at –35, the machine cannot set a high alarm above that parameter (i.e., at +15) because it cannot cross zero.
      2. Therefore, the bedside nurse must watch diligently for incidental disconnections, as the alarm may not occur swiftly. This alarm rarely occurs in the clinical setting because the pressures are usually more than 50 above or below zero.

b. **Dialysate**, or Replacement Solution Bag is Empty or Effluent Bag is Full:
   1. This is the prompt to change out that particular bag of fluid (or empty the effluent bag). That particular pump is stopped until the change has been made and "Continue" has been pressed "Continue."

c. **Caution: Incorrect Weight Change.** (Excess loss or gain of effluent, dialysate, or replacement solution weight)
   1. **Identify and correct problem before pressing continue to continue therapy.**
   2. **Access all clamps, lines, connections, ports are patent. Access for kinking or disconnection.**
   3. Ensure all fluid bags are free hanging, with no swinging.

d. Caution: Excess patient fluid loss or gain alarm.
   1. Prepare to end treatment.
   2. When ready, end treatment and return blood if not contraindicated.

TESTING OBJECTIVES:

Upon completion of the CRRT station, the nurse will be able to:

1. Demonstrate technique for preparing a venovenous dialysis catheter for use with CRRT.
2. Identify the types of therapy used in CRRT and the solutions used.
3. Properly load and prime the CRRT machine.
4. Set up the CRRT treatment per orders.
5. Determine net intake/output balances and calculate adjustments to hourly fluid removal rates to attain an ordered intake/output balance.
6. Demonstrate how to verify treatment interventions done through the CRRT machine.
7. Demonstrate proper technique in ending treatments:
   a. Return Blood
   b. Manually Return Blood
8. State three instances when the blood in the circuit would not be returned upon ending treatment.
9. Trouble-shoot the following alarms:
   a. "Air In Blood"
   b. "Filter Has Clotted"
   c. "Blood Leak Detected"
   d. "Return Line Disconnection Cannot Be Detected"
   e. Specified solution bag is full or empty caution alarm
   f. Incorrect weight change caution alarm.
   g. Incorrect weight gain or loss limit alarm.