Basic Principles of CRRT

Course Objectives

By the end of the Gambro CRRT training course the participant will be able to:

- Define CRRT and the associated therapies
- Discuss the basic CRRT principles
- Discuss the basic principles of the solute transport mechanisms
- Identify the clinical indications for administering CRRT, including an overview of patient selection
Continuous Renal Replacement Therapy (CRRT)

Any extracorporeal blood purification therapy intended to substitute for impaired renal function over an extended period of time and applied for or aimed at being applied for 24 hours/day.


Why CRRT?
CRRT closely mimics the native kidney in treating AKI and fluid overload

• Removes small and large solutes and fluid
• Replacement fluid fosters electrolyte and pH balance
• Appropriate therapy for hemodynamically unstable patients
Goals of CRRT

- Maintain fluid, electrolyte, acid/base balance, and eliminate metabolic waste (mimic native kidney function)
- Prevent further damage to kidney tissue
- CRRT is a therapy to support abnormal kidney function

Anatomy of a Hemofilter

- 4 External ports
  - Blood and dialysis fluid
- Potting material
  - Support structure
- Hollow fibers
  - Semi-permeable membrane
- Outer casing
Hemofilter: Semi-permeable membrane
Allows solutes (molecules or ions) up to a certain size to pass through

CRRT Transport Mechanisms
CRRT Modes of Therapy

- **SCUF**: Slow Continuous Ultrafiltration. Primary goal is to remove patient fluid.
- **CVVH**: Continuous Veno-Venous Hemofiltration. Primary goal is to achieve small molecule clearance, remove patient fluid.
- **CVVHD**: Continuous Veno-Venous Hemodialysis. Primary goal is to achieve small molecule clearance, remove patient fluid.
- **CVVHDF**: Continuous Veno-Venous Hemodiafiltration. Primary goal is to achieve small, medium and large molecule clearance, remove patient fluid.

All modes will assist in maintaining hemodynamic stability due to the slow fluid removal as tolerated by the patient MAP.

Molecular Transport Mechanisms

- **Fluid Transport**
  - Ultrafiltration

- **Solute Transport**
  - Diffusion
  - Convection
  - Adsorption

[Diagram showing molecular transport mechanisms]
Ultrafiltration
The movement of fluid through a semi-permeable membrane driven by a pressure gradient (hydrostatic pressure)

Diffusion = Hemodialysis
The movement of solutes only from an area of higher concentration to an area of lower concentration

* Filter has a 50K cut off
Major factors affecting diffusion

Solute removal by diffusion depends on:
- Concentration gradient blood / dialysis
- Dialysate flow rate
- Molecular size – diffusion clears small molecules
- Permeability of the membrane

Dialysate Solutions

- Flow counter-current to blood flow
- Separated from blood by a semi-permeable membrane
- Drive diffusive transport-dependent on concentration gradient and flow rate
- Facilitate removal of small solutes
- Physician prescribed
- Solution choice adjusted to meet patient needs
**How does diffusion work?**

These numbers are for example only. Clinicians must use their judgment on prescribing the correct dialysate concentration.

**Convection “Solute drag” = hemofiltration**

The forced movement of fluid with dissolved solutes (the fluid will drag the solutes)

Replacement pump is pushing fluid into the blood path (pre or post or both)

Blood pump is creating a positive pressure pushing fluid with solutes from the blood side of the filter through the semi-permeable membrane to the 'non-blood'

Effluent pump pulls the fluid with solutes from the blood side of the filter through the semi-permeable membrane to the 'non-blood'
Major factors affecting convection

Solute removal by convection depends on:
- High Membrane permeability
- Molecular size
- Degradation of filter membrane (can decrease performance)
- Replacement fluid flow rate (pressure gradient)

How Pre and/or Post Replacement work

Pre Replacement
- Pre-filter replacement solution will deliver into the blood flow at set rate.
- Blood will be diluted ↓Hct.
- The replacement “fluid volume” will be removed by the effluent pump.

Post Replacement
- The replacement “fluid volume” will be removed by the effluent pump.
- Blood will be concentrated ↑Hct.
- Post-filter replacement solution will deliver replacement solution to “replace” the removed “volume” and replenish lost electrolytes.
Why do we need to monitor Filtration Fraction percentage (FF%)?

- A FF > 25% can lead to premature filter degradation
- To decrease the FF%, prescribed fluid delivery strategies may need to be initiated such as a mix of pre- and post-dilution.
- For accurate Filtration Fraction percentage monitoring, the patient’s hematocrit should be updated once a day.


Replacement Solutions

- Infused directly into the blood at points along the blood pathway
- Drives convective transport
- Facilitates the removal of small middle and large solutes
- Physician Prescribed
- Solutions choice adjusted to meet patient needs
Considerations for solution choice

Which mode of therapy?
- CVVH: Replacement Only
- CVVHD: Dialysate Only
- CVVHDF: Both Solutions

Which anticoagulant prescribed?
- Systemic, regional or none


Adsorption
Molecular adherence to the surface or interior of the membrane.
Filter viability
Trans-membrane Pressure (TMP)

- Pressure exerted on filter membrane during operation
- Reflects pressure difference between fluid and blood compartments of filter
- Calculated by CRRT device

Trans-Membrane Pressure (TMP)

Calculated and automatically recorded:
- Entering Run mode - blood flow is stabilized
- Blood flow rate is changed
- Patient fluid removal rate is changed
- Replacement solution rate is changed
Filter viability
Filter Pressure Drop (∆P Filter)

• Change of pressure from blood entering filter and leaving filter
• Determines pressure conditions inside hollow fibers
• Calculated and automatically recorded:
  • Entering Run mode
  • Blood flow rate is changed
• Calculated by CRRT device