COMPARISON OF DIALYSIS PRESCRIPTION AND DOSE DELIVERED IN CRRT AND IHD

Dialysis Prescription

	IHD	CRRT
Membrane characteristics	Variable permeability	High permeability
Anticoagulation	Short duration	Prolonged
Blood flow rate	≥200 mL/min	<200 mL/min
Dialysate flow	≥500 mL/min	17–34 mL/min
Duration	3–4 hrs	Days
Clearance	High	Low

Dialysis Dose Delivered

	IHD	CRRT
Patient factors		
Hemodynamic stability	+++	+
Recirculation	+++	+
Infusions	++	+
Technique factors		
Blood flow	+++	++
Concentration repolarization	+	+++
Membrane clotting	+	+++
Duration	+++	+
Other factors		
Nursing errors	+	+++
Interference	+	++++

FIGURE 19-10

Comparison of dialysis prescription and dose delivered in continuous renal replacement (CRRT) and intermittent hemodialysis (IHD). The ability of each modality to achieve a particular clearance is influenced by the dialysis prescription and the operational characteristics; however, it must be recognized that there may be a significant difference between the dialysis dose prescribed and that delivered. In general, IHD techniques are limited by available time, and in catabolic patients it may not be possible to achieve a desired level of solute control even by maximizing the operational characteristics.

DRUG DOSING IN CRRT*

Drug	Normal Dose (mg/d)	Dose in CRRT (mg)
Amikacin	1050	250 qd–bid
Netilmycin	420	100–150 qd
Tobramycin	350	100 qd
Vancomycin	2000	500 qd–bid
Ceftazidime	6000	1000 bid
Cefotaxime	12,000	2000 bid
Ceftriaxone	4000	2000 qd
Ciprofloxacin	400	200 qd
Imipenem	4000	500 tid–qid
Metronidazole	2100	500 tid–qid
Piperacillin	24,000	4000 tid
Digoxin	0.29	0.10 qd
Phenobarbital	233	100 bid–qid
Phenytoin	524	250 qd–bid
Theophylline	720	600–900 qd

* Reflects doses for continuous venovenous hemofiltration with ultrafiltration rate of 20 to 30 mL/min.

FIGURE 19-11

Drug dosing in continuous renal replacement (CRRT) techniques. Drug removal in CRRT techniques is dependent upon the molecular weight of the drug and the degree of protein binding. Drugs with significant protein binding are removed minimally. Aditionally, some drugs may be removed by adsorption to the membrane. Most of the commonly used drugs require adjustments in dose to reflect the continuous removal in CRRT. (*Modified from* Kroh *et al.* [13]; with permission.)

NUTRITIONAL ASSESSMENT AND SUPPORT WITH RENAL REPLACEMENT TECHNIQUES

Parameters: Initial Assessment	IHD	CAVH/CVVH	CAVHD/CVVHDF
Energy assessment	HBE x AF x SF, or indirect calorimetry	Same	Same
Dialysate dextrose absorption	Negligible	Not applicable	43% uptake 1.5% dextrose dialysate (525 calories/D) 45% uptake 2.5% dextrose dialysate (920 calories/D) Negligible absorption with dextrose free or dialysate 0.1–0.15% dextrose
Protein assessment			
Visceral proteins	Serum prealbumin	Same	Same
Nitrogen balance: N_2 in–N_2 out	Nitrogen in: protein in TPN +/enteral solutions/6.25	Nitrogen in: same	Nitrogen in: same
	Nitrogen out: urea nitrogen appearance	Nitrogen out: ultrafiltrate urea nitrogen losses	Nitrogen out: ultrafiltrate/dialysate urea nitrogen losses
	UUN†	UUN†	UUN†
	Insensible losses	Insensible losses	Insensible losses
	Dialysis amino acid losses (1.0–1.5 N_2/dialysis therapy)	Ultrafiltrate amino acid losses (1.5–2.0 N_2/D)	Ultrafiltrate/dialysate amino acid losses (1.5–2.0 N_2/D)
Nutrition support prescription: TPN/enteral nutrition	Renal formulas with limited fluid, potassium, phosphorus, and magnesium	Standard TPN/enteral formulations. No fluid or electrolyte restrictions.	Standard TPN/enteral formulations when 0.1–0.15% dextrose dialysate used Modified formulations when 1.5–2.5% dextrose dialysate used TPN: Low-dextrose solutions to prevent carbohydrate overfeeding; amino acid concentration may be increased to meet protein requirements. Enteral: Standard formulas. May require modular protein to meet protein requirements without carbohydrate overfeeding.
Reassessment of requirements and efficacy of nutrition support			
Energy assessment	Weekly HBE x AF x SF*, or indirect calorimetry	Same	Same
Serum prealbumin	Weekly	Same	Same
Nitrogen balance	Weekly	Same	Same

* Harris Benedict equation multiplied by acimity and stress factors

† Collect 24-hour urine for UUN if UOP ≥ 400 ml/d

FIGURE 19-12

Nutritional assessment and support with renal replacement techniques. A key feature of dialysis support in acute renal failure is to permit an adequate amount of nutrition to be delivered to the patient. The modality of dialysis and operational characteristics affect the nutritional support that can be provided. Dextrose absorption occurs form the dialysate in hemodialysis and hemodiafiltration modalities and can result in hyperglycemia. Intermittent dialysis techniques are limited by time in their ability to allow unlimited nutritional support. (*From* Monson and Mehta [14]; with permission.)

Fluid Control

OPERATING CHARACTERISTICS OF CRRT: FLUID REMOVAL VERSUS FLUID REGULATION

	Fluid Removal	Fluid Regulation
Ultrafiltration rate (UFR)	To meet anticipated needs	Greater than anticipated needs
Fluid management	Adjust UFR	Adjust amount of replacement fluid
Fluid balance	Zero or negative balance	Positive, negative, or zero balance
Volume removed	Based on physician estimate	Driven by patient characteristics
Application	Easy, similar to intermittent hemodialysis	Requires specific tools and training

FIGURE 19-13

Operating characteristics of continuous renal replacement (CRRT): fluid removal versus fluid regulation. Fluid management is an integral component in the management of patients with acute renal failure in the intensive care setting. In the presence of a failing kidney, fluid removal is often a challenge that requires large doses of diuretics with a variable response. It is often necessary in this setting to institute dialysis for volume control rather than metabolic control. CRRT techniques offer a significant advantage over intermittent dialysis for fluid control [14,15]; however, if not carried out appropriately they can result in major complications. To utilize these therapies for their maximum potential it is necessary to recognize the factors that influence fluid balance and have an understanding of the principles of fluid management with these techniques. In general it is helpful to consider dialysis as a method for fluid removal and fluid regulation.

APPROACHES FOR FLUID MANAGEMENT IN CRRT

Approaches	Level 1	Level 2	Level 3
UF volume	Limited	Increase intake	Increase intake
Replacement	Minimal	Adjusted to achieve fluid balance	Adjusted to achieve fluid balance
Fluid balance	8 h	Hourly	Hourly Targeted
UF pump	Yes	Yes/No	Yes/No
Examples	SCUF/CAVHD CVVHD	CAVH/CVVH CAVHDF/CVVHDF	CAVHDF/CVVHDF CVVH
Advantages			
Simplicity	+++	++	+
Achieve fluid balance	+	+++	+++
Regulate volume changes	+	++	+++
CRRT as support	+	++	+++
Disadvantages			
Nursing effort	+	++	+++
Errors in fluid balance	+++	++	+
Hemodynamic instability	++	++	+
Fluid overload	+++	+	+

FIGURE 19-14

Approaches for fluid management in continuous renal replacement therapy (CRRT). CRRT techniques are uniquely situated in providing fluid regulation, as fluid management can be achieved with three levels of intervention [16]. In Level 1, the ultrafiltrate (UF) volume obtained is limited to match the anticipated needs for fluid balance. This calls for an estimate of the amount of fluid to be removed over 8 to 24 hours and subsequent calculation of the ultrafiltration rate. This strategy is similar to that commonly used for intermittent hemodialysis and differs only in that the time to remove fluid is 24 hours instead of 3 to 4 hours. In Level 2 the ultrafiltrate volume every hour is deliberately set to be greater than the hourly intake, and net fluid balance is achieved by hourly replacement fluid administration. In this method a greater degree of control is possible and fluid balance can be set to achieve any desired outcome. The success of this method depends on the ability to achieve ultrafiltration rates that always exceed the anticipated intake. This allows flexibility in manipulation of the fluid balance, so that for any given hour the fluid status could be net negative, positive, or balanced. A key advantage of this technique is that the net fluid balance achieved at the end of every hour is truly a reflection of the desired outcome. Level 3 extends the concept of the Level 2 intervention to target the desired net balance every hour to achieve a specific hemodynamic parameter (*eg*, central venous pressure, pulmonary artery wedge pressure, or mean arterial pressure). Once a desired value for the hemodynamic parameter is determined, fluid balance can be linked to that value. Each level has advantages and disadvantages; in general greater control calls for more effort and consequently results in improved outcomes. SCUF—ultrafiltration; CAVHD/CVVHD—continuous arteriovenous/venovenous hemodialysis; CAVH/CVVH—continuous arteriovenous/venovenous hemofiltration; CAVHDF/CVVHDF—continuous arteriovenous/venovenous hemodiafiltration.