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Principles of Hemodialysis

The term *dialysis* refers to the net movement of solutes and water across a semipermeable membrane along a concentration gradient. *Hemodialysis* is a process to remove urea, metabolic waste products, toxins, and excess fluid from the blood and correct acid–base derangements.

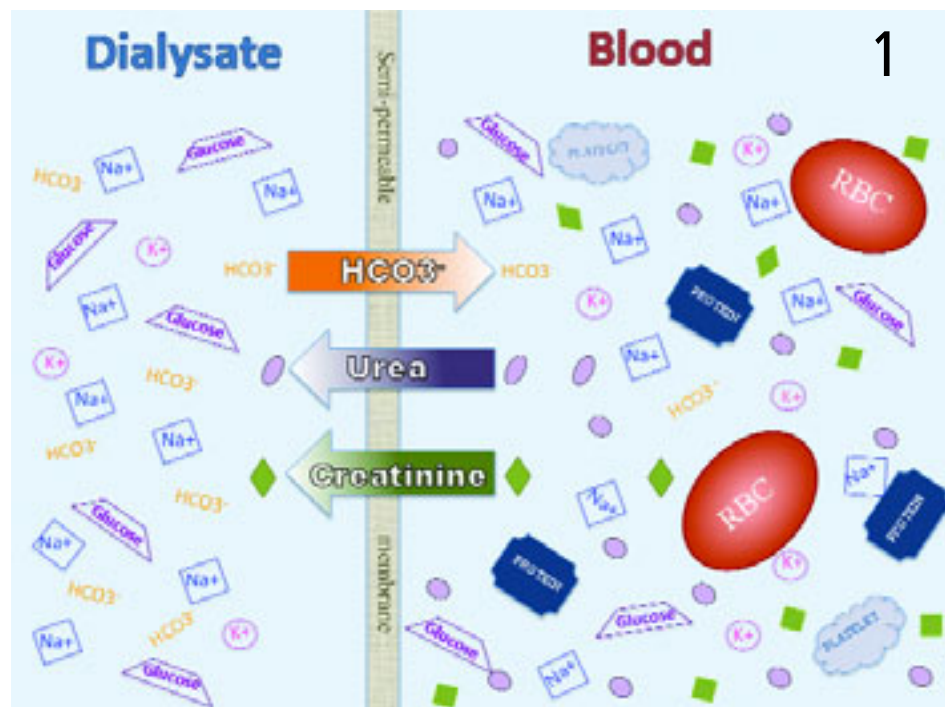
Hemodialysis (HD) works through the extracorporeal exchange of water and solutes between blood and an artificial solution—a *dialysate*—across manufactured, semipermeable membranes (**Figure 1**).

Case Selection

HD provides therapeutic benefit to 3 broad categories of veterinary patients (**Table**):

- Animals with severe uremia and its component metabolic derangements
- Animals with intractable volume overload
- Animals with some toxicoses (**Figure 2**).

The majority of patients presented for HD are acutely uremic and nonresponsive to attempted diuresis with intravenous fluids and pharmacologic manipulation. They are often volume overloaded from attempted diuresis in the face of oliguria, and many have life-threatening hyperkalemia. HD rapidly mitigates hyperkalemia and, through ultrafiltration, can restore fluid balance. It can also mitigate the clinical manifestations of chronic end-stage renal disease when conventional management fails, but few owners are financially able to continue HD indefinitely. Finally, dialytic techniques are uniquely suited to manage specific acute toxicoses.



Schematic representation of solute transport across the semipermeable dialysis membrane. The plasma concentration of urea and creatinine is high, resulting in diffusive movement down concentration gradients into the dialysate. The reverse is true of bicarbonate, resulting in net movement from dialysate into plasma.

continues

HD = hemodialysis

Table. Indications for Hemodialysis

Acute Uremia

- Anuria/oliguria nonresponsive to fluid and diuretic therapy
- Failure of conventional therapy to control biochemical or clinical manifestations of acute uremia
- Severe fluid, electrolyte, or acid–base disturbances
- Severe azotemia (serum urea nitrogen > 100 mg/dL; serum creatinine > 10 mg/dL)

Chronic Kidney Disease

- Indefinite intermittent renal replacement therapy
- Recovery from acute decompensation of chronic kidney disease
- Preoperative conditioning for renal transplantation

Other Indications

- Severe overhydration, congestive heart failure, pulmonary edema
- Acute toxicity/drug overdose

Drugs and chemicals whose physical characteristics permit passage through dialyzer membrane pores and which are not bound to plasma proteins can be quickly and efficiently removed from the bloodstream, often with a single HD session. The benefits include the ability to remove:

- Toxins already absorbed from the gut lumen
- Substances that do not adhere to enteric activated charcoal
- Both the parent compound and the active toxic metabolites.

Prognosis

The prognosis for recovery from acute uremia in dogs and cats treated with HD depends on the etiology, extent of renal damage, comorbid diseases, and presence of multiple organ system involvement. When HD is used to treat severe acute uremia, survival is approximately 50%; for infectious etiologies, 60%; for hemodynamic and metabolic etiologies, 40%; and for toxicity 20%. The outcome for dogs with acute leptospirosis is especially favorable: 85% survival is associated with either severe (dialysis-dependent) or milder forms (medically manageable) of acute renal failure.

The global survival for cats requiring HD since 1996 is reported to be 56%. Since 1996, the most common etiology of acute uremia requiring dialytic management in cats has been acute ureteral obstruction. In a report of 50 cats presented for dialytic management of acute ureteral obstruction, 70% survived to discharge. Overall, HD substantially increases the global survival for both dogs and cats with severe acute uremia beyond what would be expected with conventional management.

Referral Guidelines

Call Early, Refer Early

Clinicians at hemodialysis centers can guide the selection of patients likely to benefit from dialytic intervention and offer input on medical management of uremic animals that may not require HD. In general, patient stability and odds of a successful outcome with HD decrease the



This male cat was presented for severe oliguric acute kidney injury secondary to lily ingestion. After 3 days of intermittent HD, the cat was discharged and treated 3 times weekly. Evidence of renal recovery was noted after 2 weeks; after 3 weeks dialytic management was no longer required. The animal's renal function continued to improve. Serum creatinine concentration was 2.3 mg/dL 7 weeks after lily ingestion.

longer uremia and its attendant metabolic and fluid derangements persist. Referral for dialytic therapy is often life-saving for acutely uremic patients that do not respond to appropriate and aggressive medical management within 12 to 24 hours, and referral for dialysis is a logistical option for the clients.

Fully Inform Clients Before Referring

HD is an emotionally and financially intensive therapy with no guarantee of a successful outcome. It involves defined risk to an already compromised and often unstable patient and usually requires sequential or alternate day treatments over weeks to months. HD is an outstanding bridging mechanism that often permits life-saving repair of renal injury in patients when no other therapeutic options exist, but clients must understand that dialysis does not “fix” damaged kidneys.

It is usually impossible to determine at the outset how long therapy must continue. Generally in patients with severe acute tubular necrosis, clients should be financially and emotionally prepared to undertake 2 to 4 weeks of dialytic therapy, although some patients recover more quickly. Conversely, some patients recover renal function only after many months of dialysis dependency, and some never recover.

As noted earlier, prognosis and duration of therapy vary tremendously and depend on etiology and degree of renal insult, as well as patient condition and comorbidities. Dialysis referral centers can often provide written and verbal information to clients to ensure they are fully and accurately educated regarding the advantages and limitations of dialytic intervention.

Spare the Jugular Veins

Blood flow rates required to perform HD mandate placement of a large-gauge jugular catheter, with portals ideally situated in the right atrium or cranial vena cava. The condition of the jugular veins on presentation often determines use of a percutaneous catheter versus surgical catheter placement, and use of local versus gen-

eral anesthesia. Additionally, regardless of placement method, prior trauma to the vein increases the odds of placement-related complications such as venous tearing.

For these reasons, jugular venipuncture and use of jugular catheters should be avoided in patients where HD remains an option. If jugular vein access is unavoidable, use of the left jugular vein is preferred (sparing the right jugular vein completely) and adequate hemostasis following venipuncture is essential to avoid hematoma formation.

Availability of Treatment

HD is delivered intermittently—typically for 3 to 5 hours, 3 to 4 times per week—or as continuous renal replacement therapy (CRRT). Because CRRT is a relatively new option in veterinary medicine, safety and efficacy data are limited. However, evidence in human medicine suggests that intermittent and continuous dialytic therapies are equally effective for the treatment of acute renal failure.

Each modality has its strengths and weaknesses and the choice of technique is tailored to the needs of the patient, the resources of the institution, and the expertise of the clinician. As awareness of the utility and availability of dialytic therapy increases among veterinarians and pet owners and the number of veterinary dialysis facilities increases, dialytic management will become the standard of advanced care for animals with severe, intractable uremia.

Four facilities in North America offer intermittent HD for companion animals, and 7 offer CRRT (see **Aids & Resources**). University of California–Davis provides postresidency training in nephrology and renal replacement modalities. ■

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