Pharmacology

for Allied Health Sciences

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JAYPEE

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SECTION 14

Special Topics

SECTION OUTLINE

- Special Topics for Renal Dialysis Technology
- Special Topics for Operation Theater Technology and Anesthesia Technology
- Special Topics for Emergency and Trauma Care Technology
- Medication Errors

SPECIAL TOPICS FOR RENAL DIALYSIS TECHNOLOGY

1. ANTIBIOTICS IN PATIENTS WITH CATHETER ASSOCIATED INFECTIONS AND PERITONITIS

Infections are a major problem with venous catheters, and is the primary cause of catheter failure, leading to higher morbidity and death. In most cases, infections occur due to contamination of the catheter connectors, and lumen during dialysis, or from infused solutions. Also, infections can arise when the bacteria from patient's skin and outer surface of the catheter penetrate through the puncture site. Occasionally, catheters may also become colonized by bacteria from distant sites during bacteremia.

Sites of Infection

1. Exit-site Infection

It should be suspected when there is erythema, discharge, crusting, and tenderness at the catheter exit site, without tunnel tenderness or purulence. Treatment includes oral antibiotics along with topical antibiotic cream. These infections can be prevented by proper care of the exit site. The catheter should be removed if:

- Systemic signs of infection appear, such as leukocytosis or fever.
- If pus is present along the catheter track.
- If the infection persists or recurs after initial antibiotic treatment.
- If blood cultures are positive.

2. Tunnel Infection

It occurs along the subcutaneous tunnel, extending from the cuff towards the insertion site and venotomy. There could be significant tenderness, swelling, and erythema along the catheter tract, often accompanied by purulent drainage from the exit site. Such infections can lead to systemic bacteremia. If there are signs of systemic infection, the catheter should be removed immediately, and antibiotic therapy started.

3. Bloodstream Infection

In catheter related blood stream infections **(CRBSI)**, patients may present with signs and symptoms of systemic infection. Mild infection leads to fever and chills, while more severe cases can lead to hemodynamic instability. Some patients may develop infection symptoms after starting dialysis, indicating a systemic spread of bacteria and/or release of endotoxins from the catheter. Signs of endocarditis, osteomyelitis, epidural abscess, and septic arthritis may also be present. While gram-positive organisms are the most common cause, a significant number of cases involve gram-negative infections as well.

Treatment

Sample should be sent for culture and sensitivity before starting treatment. Empirical antibiotic treatment includes vancomycin with gentamicin. Ceftazidime and cefazolin are alternatives. Once the culture report is available, can be switched over to suitable antibiotics.

If candida infection is suspected, an echinocandin - caspofungin, micafungin or anidulafungin may be considered. Fluconazole and amphotericin are alternatives.

Antibiotic Locks

Antibiotic lock is filling the catheter lumen with an antibiotic solution and retaining it for a given duration in order to sterilize the catheter. Antibiotic lock therapy is recommended for patients with CRBSI involving long-term catheters, if there are no signs of exit-site or tunnel infection and catheter salvage is needed. It should be used along with systemic

antimicrobial therapy, with both administered for 7–14 days.

However, if CRBSI is caused by *Staphylococcus aureus* or *Candida,* the catheter should be removed.

In cases where multiple catheter-drawn blood cultures test positive for staphylococci or gram-negative bacilli but peripheral blood cultures are negative, antibiotic lock therapy can be given without systemic antibiotics for 10–14 days. Vancomycin lock solutions should have a concentration at least 1,000 times higher than the concerned minimum inhibitory concentration (MIC). Some examples of antibiotic lock solution concentrations are vancomycin 2.5–5.0 mg/mL, gentamicin 1 mg/mL + vancomycin 2.5 mg/mL, cefazolin 5 mg/mL, amikacin 25 mg/mL. When combinations are used, compatibility of the drugs should be kept in mind.

In patients with CRBSI, if catheter has to be kept in place, antibiotic lock therapy can be tried along with systemic antimicrobial therapy—both to be continued for 7–14 days. The antibiotic lock solution should be replaced every 24 hours for ambulatory patients with femoral catheters, and every 48 hours if needed. For hemodialysis patients, the lock solution can be replaced after each dialysis session.

Peritonitis

Patients undergoing **continuous ambulatory peritoneal dialysis** (CAPD) may develop peritonitis which could complicate treatment and may also lead to treatment failure. When signs and symptoms of peritonitis and elevated peritoneal fluid neutrophil levels are present, effort should be made to identify the causative organisms by culture and sensitivity. Though gram positive bacteria are the common causative agents, gram-negative microbes and fungal peritonitis may also occur.

Treatment

1. Empiric Antibiotic Therapy

To target both gram-positive and gram-negative organisms should be used.
Vancomycin/cefazoline + ceftazidime/an aminoglycoside → first line regimen.

2. CAPD

a. Drain abdomen and send sample from drainage bag for cell count and culture. Change the transfer set
b. Loading dose: Infuse 2-L dialysis solution containing 1,000 mg ceftazidime, 1,000 mg cefazolin, and 1,000 units of heparin
c. Allow to dwell for 3–4 hours. In patients who appear septic, loading doses should be given IV rather than IP.

Continuous dosing method: Regular CAPD schedule should be continued using normal exchange volume if tolerated. Add 125 mg/L ceftazidime, 125 mg/L cefazolin, and 500–1,000 units/L heparin to each dialysis solution bag.

Intermittent dosing method: Continue regular CAPD schedule, using normal exchange volume if tolerated. Administer ceftazidime 1,000 mg and cefazolin 1,000 mg into each nocturnal exchange. If fibrin or blood is present in dialysate, add heparin to every exchange. Intraperitoneal antibiotics are given into peritoneal fluid for 8 hours.

Stability of Antibiotics in Dialysate

Vancomycin, aminoglycosides, and cephalosporins can be combined in the same dialysis solution bag, but aminoglycosides are incompatible with penicillins. Vancomycin (25 mg/L) remains stable for 28 days when stored at room temperature, though higher ambient temperatures shorten its stability. Gentamicin (8 mg/L) is stable for 14 days, but its stability decreases when mixed with heparin. Cefazolin (500 mg/L) stays stable for at least 8 days at room temperature or up to 14 days when refrigerated, with no reduction in stability

when heparin is added. Ceftazidime, however, is less stable; concentrations of 125 mg/L last for 4 days at room temperature or 7 days when refrigerated, while concentrations of 200 mg/L are stable for 10 days if kept refrigerated.

Nystatin: Fungal prophylaxis given during antibiotic therapy with nystatin may help prevent *Candida* peritonitis.

2. DIALYZABLE DRUGS

Drug dialyzability is the extent to which a drug is removed by dialysis. It depends on many factors including pharmacokinetic characteristics of drug and technical aspects of the dialysis system.

In drug overdosage, dialysis can be life-saving, particularly when antidotes are not available. For drugs such as salicylates, valproate, metformin, lithium and alcohol intoxication, dialysis may be needed.

Factors Influencing Drug Dialyzability

1. Molecular weight: Small molecular weight substances will pass through the dialysis membrane more easily than larger molecular weight drugs.
2. Protein binding: Drugs with high degree of protein binding are poorly dialysable.
3. Volume of distribution: Drugs with large volume of distribution are poorly dialysable.
4. Plasma clearance: Increasing plasma clearance will decrease dialysis clearance.
5. Dialysis flow rates: Greater degree of dialysis is achieved with faster dialysis flow rates.

Common Agents that can be Dialyzed in Overdose

Alcohols

Standard hemodialysis is the first line therapy in methanol and ethylene glycol poisoning. The small molecular size, low volume of distribution, low plasma protein binding make it favorable for dialysis.

Paracetamol

As paracetamol is a commonly used drug and easily available over-the-counter, poisoning is also quite common. If not treated promptly, it can be fatal. 10 G of paracetamol can cause serious toxicity. Antidote for paracetamol poisoning is N-acetylcysteine. However, if the plasma levels of paracetamol are too high, dialysis is required to clear it.

Barbiturates

There is no antidote for the treatment of barbiturate overdose. Treatment is largely symptomatic. However, barbiturate poisoning can be rapidly fatal as it is a profound respiratory depressant. Dialysis can be life-saving in barbiturate poisoning.

Lithium

It is a drug used in bipolar mood disorder and has a narrow therapeutic index. Dialysis is considered in patient with lithium levels >4 mEq/L.

Metformin

It is a commonly used oral antidiabetic drug; pharmacokinetics of metformin are favorable for hemodialysis.

Salicylates

These are acidic drugs and have no antidote. Dialysis is needed in poisoning.

Valproic Acid and Carbamazepine

These are used in the treatment of epilepsy and bipolar mood disorder. For valproate dialysis should be considered in severe toxicity with plasma levels more than 1,300 mg/L. In carbamazepine overdose, hemodialysis may reduce carbamazepine level by 50%.

Dabigatran

It is a new oral anticoagulant agent. Idaricizumab is the recently developed antidote to reverse the effects of dabigatran toxicity. However, it is expensive and may not be readily available. Hemodialysis may be considered as a method of removing dabigatran and reducing its anticoagulant effects.

Isoniazid

It is an antitubercular drug and **theophylline** are other dialyzable drugs. Theophylline a bronchodilator is also a CNS stimulant. Both are dialyzable drugs.

3. ERYTHROPOIETIN

Erythropoiesis is the process by which the body makes red blood cells. Erythropoietin (EPO) is produced by the kidney in response to hypoxia and anemia.

In patients with chronic kidney disease (CKD) anemia is common which is due to a lack of erythropoietin, iron deficiency, and inflammation. Anemia can be treated by **erythropoiesis-stimulating agents (ESA)**, or using the drugs that stimulate red blood cell production and also treating iron deficiency and inflammation.

Mechanism of Action

Erythropoietin is a glycoprotein hormone produced by the peritubular cells of the renal cortex. When the body has low oxygen or in anemia, the kidneys quickly release EPO. It binds to erythropoietin receptors on red cell progenitors and stimulates red cell production. This hormone helps red blood cells mature and produce hemoglobin, which carries oxygen in the blood.

The response to epoetin therapy is poor in cases of primary bone marrow disorders and nutritional anemias, as endogenous EPO levels are already elevated in these conditions.

ESA Therapy

Erythropoietin treatment should be started only when haemoglobin levels fall below 10 g/dL. The goal is to keep hemoglobin between 9 and 11.5 g/dL and one important aim is to avoid the need for blood transfusions.

Types of Erythropoietin

- Short-acting: Epoetin alfa.
- Long-acting: Darbepoetin alfa, Epoetin beta.

Epoetin alfa is a recombinant human erythropoietin approved in 1989 and widely available globally. This short-acting ESA has a half-life of approximately 8 hours when given IV, while subcutaneous administration extends the half-life to 16–24 hours. In patients with CKD, dose ranges from 4,000 to 6,000 units subcutaneously once a week. It is not cleared by dialysis.

Darbepoetin alfa is a modified form of erythropoietin and is longer acting. It has a half-life of approximately 25 hours when administered intravenously and 50 hours given subcutaneously. In stable CKD patients darbepoetin alfa should be given either once weekly (dose 20–30 μg) or every two weeks (40–60 μg).

Epoetin beta is attached to polyethylene glycol polymer is much more longer acting.

Continuous erythropoietin receptor activator (CERA): It is a modified form of epoetin beta, where a polyethylene glycol (PEG) group has been added. It has an extended half-life of approximately 136 hours. CERA is administered every 2 weeks for the correction of anemia, followed by once a month during the maintenance phase, dose: 150 μg per month.

Monitoring in EPO Therapy

Hemoglobin and transfusion levels should be documented before initiating ESA therapy. Hemoglobin levels should be checked weekly after beginning treatment.

Adverse Effects

A sudden increase in hematocrit, can lead to raised blood viscosity, and peripheral vascular resistance (due to the correction of anemia) and thus can result in several complications. These include increased clot formation in arteriovenous shunts (common in dialysis patients) hypertension, serious thromboembolic events including MI, stroke and venous thrombolysis and occasionally seizures. Some patients may also experience flu-like symptoms lasting 2–4 hours.

Precautions and Contraindications

- Uncontrolled hypertension
- Coronary artery disease/heart failure
- History of stroke
- Active malignancy.
- Severe allergic reactions

Uses

- Erythropoietin preparations are used in the treatment of anemia due to:
  - Chronic renal failure
  - Anemia in AIDS patients
  - Cancer chemotherapy
  - Aplastic anemia
  - Multiple myeloma and cancers of bone marrow
  - Chronic inflammatory conditions
- To reduce the need for blood transfusion in high-risk patients undergoing certain surgeries
- Treatment of iron overload
- Anemia of prematurity

4. PHOSPHATE BINDERS

Kidney plays an important role in the regulation of serum calcium and phosphate levels. In patients with chronic kidney disease (CKD), many processes that are involved in calcium, phosphorous and bone metabolism are affected. Advanced stages of CKD have hyperphosphatemia due to reduced excretion of phosphate. Moreover, high protein diet further increases plasma phosphate levels. This can lead to complications like calcium deposition in the vessel walls, hyperparathyroidism, renal osteodystrophy and thereby increased mortality.

Oral phosphate binders are used to reduce hyperphosphatemia in CKD patients. These drugs lower serum phosphate levels by reducing intestinal absorption of dietary phosphate. Oral phosphate binders may provide symptomatic relief from pruritus and red irritated eyes, which are common in patients with high serum phosphate levels. Phosphate-rich foods with a high phosphate to protein ratio (processed foods, fast foods) should be avoided but foods with a high biologic value (e.g., meats and eggs) should be retained to maintain nutritional status.

Other medicines should be given separately with a gap as phosphate binders can interfere with the absorption of drugs such as oral iron and ciprofloxacin.

Types of Phosphate Binders (Fig. 14.1)

Mechanism of Action

Phosphate binders decrease the intestinal absorption of phosphate by binding dietary phosphorous, promote excretion and thereby lower serum phosphate levels.

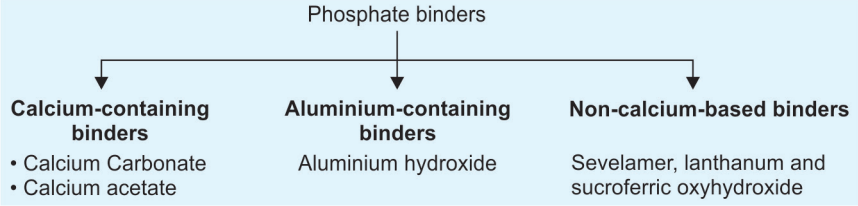
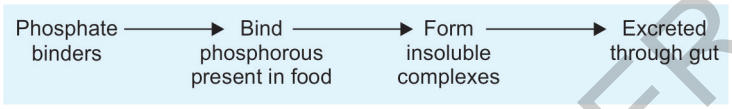


Fig. 14.1: Types of phosphate binders.



Calcium-Containing Phosphate Binders

Calcium carbonate acts by forming insoluble phosphate complexes in the gut. Calcium compounds also act as calcium supplements and help to overcome hypocalcemia in CKD patients.

Adverse effects: Gastrointestinal upset, particularly constipation, hypercalcemia and accelerated vascular calcification are the main concerns when they are combined with vitamin D therapy.

Aluminium-based Binders

Aluminium hydroxide can bind phosphates extensively and at a wide range of pH. If calcium is to be avoided, aluminium hydroxide is the suitable phosphate binder. Aluminium hydroxide acts by forming insoluble phosphate complexes in the gut.

Adverse effects: Long-term use should be avoided because it could result in aluminium poisoning with dementia, microcytic anemia, osteomalacia, and gastrointestinal disturbances.

Non-calcium-based Binders

Sevelamer hydrochloride: It is a non-calcium-based phosphate binder, but has a lower phosphate-binding capacity than other phosphate binders. Additional benefits include lowering serum LDL cholesterol and increasing the concentrations of fetuin-A (calcification inhibitor). However, it is expensive and can cause gastrointestinal disturbances and metabolic acidosis. It may also reduce the bioavailability of fat-soluble vitamins.

Lanthanum Carbonate

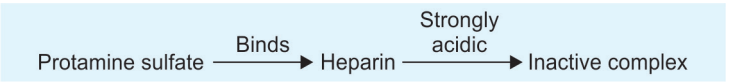
It is a trivalent metal phosphate binder which has a similar affinity for phosphate as aluminium-based drugs. It is very effective and the powder form is more effective than chewable tablets. Lanthanum may get deposited in tissues, particularly liver and bone. It causes gastrointestinal intolerance, particularly nausea and is expensive.

Sucroferric Oxyhydroxide

It is an iron-based phosphate binder for patients with chronic kidney disease on dialysis. Phosphate binding occurs across a wide range of pH with a peak at 2.5 in the stomach. Common adverse effects include diarrhea and change in stool color.

5. PROTAMINE SULFATE

Patients undergoing dialysis, are regularly given heparin and the effect of heparin will reduce as heparin gets metabolized in the body. Sometimes, post-dialysis patients may have bleeding due to overdose of heparin and antidote may then be required to



reverse it. Also in CRRT patients, immediate reversal of heparin action may be required. Protamine sulfate is the specific antidote for heparin overdosage. It is a strongly basic, low molecular weight protein that neutralizes heparin, which is strongly acidic. Protamine neutralizes heparin on a weight-for-weight basis (1 mg of protamine sulfate for every 100 U of heparin).

In the absence of heparin, protamine can act as a mild anticoagulant by interacting with platelets and fibrinogen. Hence protamine overdose should be avoided.

Indications

Protamine sulfate is used to reverse the anticoagulant effect of heparin:

- Before surgery
- After renal dialysis
- After open-heart surgery
- In cases of excessive bleeding,
- Accidental heparin overdose
- Topical: Protamine sulfate may be used topically to stop bleeding fistulae.

Administration and Dose

Protamine sulfate injection should be given slowly through an IV cannula over about 10 minutes, and the total dose should not exceed 50 mg. The amount of protamine depends on the heparin dose-1 mg of protamine sulfate neutralizes 100 units of heparin

Since heparin is also metabolized in the body, the dose of protamine should be reduced if more than 15 minutes have passed after the heparin injection. Ideally, the dose should be adjusted based on clotting tests. In large amounts, protamine itself acts as an anticoagulant and therefore its overdose should be avoided.

Steps in Administering Protamine Sulfate

1. **Determine the total units of heparin administered**: Consider the dose received, rate of heparin infusion and the total duration of administration.
2. **Calculate the total protamine required**: 1 mg of protamine sulfate for every 100 U of heparin.
3. Administer **50%** of the estimated dose.
4. Do not exceed a total dose of 50 mg of protamine sulphate.

Precautions

- Avoid rapid administration
- Use carefully in fish allergy
- Increased risk of allergy especially if already used earlier.
- To be used carefully in infertile, vasectomized men; to be used carefully in prolonged procedures; pregnancy, lactation and children.
- Avoid protamine sulfate overdose not suitable for reversing the effect of oral anticoagulants.
- If multiple doses are required, clotting parameters should be monitored
- If bleeding continues, fresh frozen plasma or whole blood should be given

Adverse Reactions

Hypotension, bradycardia, pulmonary/systemic hypertension, dyspnea, pulmonary edema, protamine sulfate can cause histamine release in the body, leading to hypersensitivity reactions—anaphylaxis and flushing. Other symptoms reported are fatigue, nausea, vomiting and back pain.

6. VACCINES AND IMMUNIZATION

Vaccines stimulate the host immune system and have saved millions of lives. Vaccines are suspensions of microorganisms (dead or live attenuated) which stimulate the immunological defence of the host by developing antibodies.

Toxoids are bacterial exotoxins modified to remove toxicity but retain antigenicity. Antisera contain antibodies against a particular microorganism—they provide passive immunity. Antisera like tetanus antitoxin, gas gangrene, antitoxin, diphtheria and antirabies sera are obtained from sera of horses which are actively immunized against the specific organism. Sensitivity tests should be done before giving antisera. Allergic reactions may occur because of the animal source.

Immunoglobulins (Ig) are human gammaglobulins that carry the antibodies—like normal human gammaglobulin, tetanus Ig, rabies Ig, anti-diphtheria Ig and hepatitis-B Ig. Allergic reactions including serum sickness and anaphylaxis can occur with antisera, while it is uncommon with Igs.

Active immunization is the administration of antigen to the host in order to induce antibody production. Vaccines are used for active immunization. They impart active immunity, which takes sometime to develop and are, therefore, used prophylactically. The antibodies so developed destroy the specific microorganism when it enters the body.

Passive immunization is imparting immunity to a host passively by the transfer of antibodies, e.g., antisera and immunoglobulins (Ig). This affords immediate protection because readymade antibodies are available.

Primary immunization provides primary immunity and is usually given in children, e.g., DPT (triple antigen given to infants).

Secondary immunization is done to reinforce the primary immunity by giving booster doses.

Vaccines in Dialysis Patients

Patients on dialysis have an increased risk of infection, which can lead to more serious complications. For this reason, vaccines are a crucial part of health care for dialysis patients. Some vaccines require booster doses to maintain sufficient antibody levels.

Recommended vaccines for people on dialysis include the flu vaccine, hepatitis B vaccine, pneumococcal vaccines, and the DPT vaccine (diphtheria, pertussis, tetanus).

Flu (Influenza) Vaccine

The flu shot is highly recommended, particularly for kidney patients by the National Kidney Foundation (NKF) and the Centers for Disease Control and Prevention (CDC). It should be administered annually, ideally before the end of October. Since people on dialysis have a higher chance of contracting the flu, annual vaccination is essential.

Hepatitis B Vaccine

Hepatitis B symptoms can resemble flu but may also cause jaundice. Chronic hepatitis B infection can lead to liver failure and even cancer. Dialysis patients have a low chance of contracting hepatitis B due to strict infection control measures. However, vaccination is needed to avoid any risk. Dialysis patients should receive a higher dose of the hepatitis B vaccine, with a series of four shots given over several months.

Pneumococcal Vaccine

There are two types of pneumococcal vaccines: PPSV23 and PCV13, both of which are recommended for dialysis patients.

DPT Vaccine (Diphtheria, Pertussis, Tetanus)

The DPT vaccine protects against three bacterial infections: diphtheria, pertussis and tetanus. Tetanus can be contracted through wounds, while diphtheria and pertussis are spread through person-to-person contact.

Table 14.1: Vaccines recommended for adults on dialysis.

Vaccine	*Dosage*
Flu (influenza)	1 dose per year
Hepatitis B virus (HBV)	3 doses
Hepatitis A virus (HAV)	2 doses
Pneumococcal pneumonia (2 types of vaccines)	1 or 2 doses
Diphtheria, pertussis and tetanus (DPT)	1 dose of DPT Booster Td every 10 years
Measles, mumps and rubella (MMR)	1 or 2 doses
Human papillomavirus (HPV)	Female: 3 doses up to age 26 Male: 3 doses up to age 21
Haemophilus influenzae type B (Hib)	1 or 3 doses
Varicella (chickenpox)	1 dose
Meningococcal (meningitis)	Use if needed, 1 or more doses

Other Vaccinations

Additional vaccines that may be recommended for dialysis patients include those for measles, mumps, rubella (MMR), varicella (chickenpox), meningococcus, and human papillomavirus (HPV) **(Table 14.1)**. Hepatitis A vaccination is also advised to protect against the hepatitis A virus, which affects the liver and can spread through contaminated food or water.

7. DRUGS AND DIALYSIS

Many drugs are mostly eliminated by the kidneys. In chronic kidney disease (CKD), GFR is reduced and drugs may require dose adjustment to avoid toxic levels. If 30% or more of a drug is eliminated unchanged in the urine, it will need dose adjustment in CKD stages 3 to 5.

Factors that influence dosing adjustments in CKD are:

- Drug elimination
- Volume of distribution of the drug
- Physiologic and biochemical changes that affect plasma protein binding and tissue binding
- Altered CYP450 enzyme activity

Hemodialysis (HD) is used for the management of fluid overload and removal of uremic toxins in patients with acute kidney injury, CKD and many other conditions. In general, hemodialysis is more effective in removing drugs than peritoneal dialysis. Hemodialysis may alter drug dosing.

Dializability of drugs should be considered before administering drugs to the patients on dialysis

Factors that affect drug dializability are:

- **Drug related factors:**
  - *Molecular weight/size:* Drugs with high molecular weight and large molecules are not cleared by HD.
  - *Degree of protein binding:* Drugs that are small but highly protein bound (>90%) are not well dialyzed because both binding proteins viz α acid glycoprotein and albumin have high molecular weight, e.g., apixaban which is >90% protein bound is not removed by HD.
  - *Volume of distribution:* Drugs with high volume of distribution (> 2L/kg) such as ciprofloxacin and chloroquine are poorly removed by HD.
  - *Dialysis filters:* Compared to conventional dialysis filters many drugs are cleared by high flux dialysis because they are more polar.

Examples of drugs that are cleared in high flux dialysis and not by conventional dialysis filters are:

Carbamazepine → Ranitidine → Tramadol
Cisplatin → Valproic acid → Enoxaparin
Sorafenib

Hemodialysis also greatly affects the clearance of a drug. The primary factors that are important and vary between patients are the composition of the dialysis filters, the filter surface area, the blood, dialysate and ultrafiltration flow rates and whether or not the dialysis unit reuses the dialysis filter.

Principles of drug dosing in CKD patients undergoing HD (Table 14.2):

- To reduce the loss of drug that would result from the additional clearance during HD, **administer drugs after** the patient has received dialysis.
- Administration of **antihypertensive drugs** and vasoactive drugs should be **avoided in the hours before a HD** session to minimize the likelihood of hypotension.
- Medications for pain are given irrespective of dialysis time.
- For some drugs, higher dose may be needed to compensate for the additional loss of drug during the dialysis procedure, e.g., vancomycin.
- Aminoglycosides and vancomycin are to be administered during or immediately prior to HD.
- **For anticancer drugs,** performing HD immediately after administration of the drugs is a good option.

Table 14.2: Drug dosing guidelines of some commonly used drugs in CKD patients on dialysis.

Drug	*Regimen for normal renal function*	*Intermittent hemodialysis (IHD) dosing*
Amlodipine	5 mg daily	No adjustment necessary
Apixaban	Indication dependent 2.5–10 mg every 12 hr	5 mg twice daily; 2.5 mg twice daily if age >79 years or body weight <61 kg
Atorvastatin	10 mg daily	—
Dabigatran	Indication dependent Starting dose: 75–110 mg MD 150–220 mg daily	Not recommended
Metformin	0.5–1 g every 12 h	Avoid
Ramipril	2.5–10 mg daily	25%
Amoxicillin	0.5–1.0 g every 8 h	0.25–0.5 g daily
Amoxicillin-clavulanate	500/125 mg every 8 h	Every 12–24 h
Azithromycin	250–500 mg every 24 h	100% dose after dialysis
Ceftriaxone	1 g every 24 h	100% dose after dialysis
Ceftazidime	1–2 g every 8-12 h	1 g after dialysis
Ciprofloxacin	400 mg every 8–12 h (IV) 500–750 mg every 12 h (oral)	200–400 daily 50%
Metronidazole	250–500 mg every 8–12 h	Dose after dialysis
Penicillin G	1–4 million U every 4–6 h	LD: Usual dose MD: 25–50% every 4–6 h or 50–100% every 8–12 h
Vancomycin	15–20 mg/kg every 8–12 h	LD: 15–25 mg/kg MD: 5–10 mg/kg (after IHD)

LD: loading dose; MD: maintenance dose; h: hour

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