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Perioperative Management of Patients on Hemodialysis: A Practical Guide

Özant Helvacı, Ülver Derici

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Department of Nephrology, Gazi University School of Medicine, Ankara, Turkey

Abstract

Hemodialysis is the most common form of renal replacement therapy employed in approximately 4 million patients worldwide. Patients on hemodialysis may need elective or emergent surgery related or unrelated to end-stage renal disease. These patients are at an increased risk of perioperative morbidity and mortality. Successful outcomes require meticulous multidisciplinary teamwork coordinated by a nephrologist. The scarcity of studies further complicates this task. In this practical guide, we briefly summarize the available data.

Keywords: Dialysis, end-stage renal disease, hemodialysis, surgery

Corresponding Author: Özant Helvacı ✉ drozant@hotmail.com

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INTRODUCTION

Hemodialysis is the most common renal replacement therapy that has been employed in approximately 4 million patients worldwide. Patients on hemodialysis may need an elective or emergent surgery that is related or unrelated to end-stage renal disease (ESRD). These patients are at an increased risk of perioperative morbidity and mortality (1, 2). Successful outcomes require meticulous multidisciplinary teamwork coordinated by a nephrologist. However, the scarcity of studies on this topic further complicates this task. In this practical guide, we briefly summarize the available data.

Decision Making

A shared decision-making process is crucial before any surgery. Less invasive methods should be considered when available (e.g., coronary artery bypass grafting vs. percutaneous coronary intervention and laparotomy vs. laparoscopy). Moreover, regional or local methods should be preferred over general anesthesia when applicable.

Timing and Logistics

A common practice is to carry out dialysis on the day before surgery, which generally allows optimal volume, electrolyte control, and heparin clearance and corrects the bleeding diathesis. Some procedures may immobilize the patient, creating a need for bedside dialysis. Sessions can continue on the day after surgery unless urgent indications develop (1, 2). For hemodynamically unstable patients, a temporary switch to continuous renal replacement therapy (CRRT) seems logical.

Cardiovascular Evaluation

Cardiac problems are particularly common in patients on hemodialysis. Most cases are asymptomatic because of diabetes or exercise intolerance. High-risk patients require a cardiology consultation. Revascularization should be pursued, although the effects on survival are unclear (2). Hence, an increased risk of acute coronary syndromes in the postoperative state needs a vigilant follow-up.

Hemodialysis Optimization

Perfect volume control is a sine qua non in obtaining satisfactory results. Patients over their "dry weight" may suffer from cardiac/noncardiac complications, whereas those below their "dry weight" may experience profound hypotension with anesthesia induction. The volume control also helps blood pressure (BP) management. BP levels <140/90 (predialytic) and <130/80 (postdialytic) may be valid in surgical settings (2, 3). Renin-angiotensin-aldosterone system blockers and long-acting calcium channel blockers should be discontinued on the day of surgery because they can cause severe hypotension. Furthermore, dialysis adequacy should be at the recommended levels before performing the elective procedures. Optimum erythropoietin (EPO) dosing is important to limit transfusions.

Electrolytes

Sodium, calcium, and phosphorus should be in the normal range. A K^+ threshold of <5.5 mmol/L is safe for elective procedures. Patients with K^+ levels <6 mEq/L and with no electrocardiograhy (ECG) changes may be fit for surgery in emergencies. When K^+ levels >6 mEq/L or ECG changes are present, a 2-h dialysis will correct hyperkalemia in most cases (1, 2, 4). With time constraints, the aggressive use of calcium, sodium bicarbonate, insulin, β-adrenergic inhalers, and intraoperative K^+ monitoring is warranted (Table 1). Some of these agents have a diminished efficacy in the hemodialysis setting. Hypokalemia should also be avoided, especially when the patient belongs to the "nothing by mouth" category. High K^+ baths shall be used when necessary. Another less preferred method is to infuse KCl or KPO_4 during hemodialysis. The latter also corrects hypophosphatemia, if present.

Bleeding

Patients on hemodialysis are at an increased risk of perioperative bleeding, attributed to uremic platelet dysfunction and medications. The effects of heparin disappear after 4-6 h, and reversal with protamine is possible in urgent situations. Aspirin, clopidogrel, and warfarin should be withdrawn appropriately. The use of newer antiaggregants, such as prasugrel and ticagrelor, in patients on hemodialysis lacks adequate data. In addition, direct oral anticoagulants, except apixaban, need to be avoided. Low-molecular-weight heparins are not recommended; dose reductions and anti-Xa monitoring are required, if used in ESRD. Desmopressin and cryoprecipitate improve platelet function and may be used immediately before surgery. Other studies have also reported anecdotal success with conjugated estrogens, tranexamic acid, and platelet transfusions. The data are summarized in Table 2 (1, 2, 5-8).

Main Points

- Perioperative management of a patient on hemodialysis is a complex task.
- This article covers basic principles for achieving successful outcomes.
- Physcians should consider issues related to end-stage renal disease, dialysis, and medications.
- Each surgery is a unique experience, hence a case-by-case management strategy must be employed.

Anesthesia

Local or regional anesthesia is safer than general anesthesia and is, thus, the modality of choice for access creation (9). Epidural techniques and lumbar blocks have been successfully used for cesarean sections and renal transplantation. Moreover, local anesthetics may have a delayed onset and prolonged duration of action owing to their low bicarbonate levels. The renal considerations of drugs used in general anesthesia induction and maintenance are detailed in Table 3 (1, 2).

Access Protection

Arteriovenous fistula (AVF) is a lifeline of a patient on hemodialysis that must be protected at all times. The AVF should be free of BP monitoring, positional pressure, and venous or arterial lines. The dorsal veins of the hand should be preferred when necessary. In the rarest instance of an emergent surgery, when no other access is available, an experienced hemodialysis nurse should cannulate the venous site of the fistula. These principles also apply to arteriovenous grafts (AVGs). Proper monitoring and early detection of an AVF/AVG dysfunction are essential for the salvation of the access. The surgical team should be aware of the existing central venous stenosis. Moreover, hemodialysis catheters should not be used for any other purpose as a general rule.

Monitoring

The central venous pressure and pulmonary arterial wedge pressure are of limited value for patients on hemodialysis (1). Experts claim that a "goal-directed therapy" with stroke volume variation and venous oxygen saturation levels may be beneficial (2). However, there is no standard method. Each institution must employ a hemodynamic monitoring system with the available instruments. However, a detailed discussion of this matter is beyond the scope of this article.

Fluids

The choice of preference between crystalloids and colloids has no definite evidence. However, starch derivatives may be harmful, especially in transplant surgery (10, 11). Frequently used crystalloids, including normal saline, Ringer's lactate, and 5% dextrose, may cause metabolic acidosis, hyperkalemia, and hyponatremia, respectively. Intravenous infusions should not exceed the ongoing bleeding and predicted blood losses to prevent acute fluid overload.

Transfusions

Even a single transfusion can induce antihuman leukocyte antigens antibodies, which may hamper a patient's future transplantation chances (12). Increasing the EPO dose a week before

Table 1. Management of perioperative hyperkalemia

Hyperkalemia	Drug/intervention	Comment
K+ >6.5 or K+ >6 and ECG changes	Hemodialysis	Fastest measure to lower K
		2-h session is generally enough
		Stop insulin infusion when on hemodialysis
	IV 10% calcium gluconate	Does not lower K^+, a temporary measure to prevent VT/cardiac arrest
	IV insulin	In dextrose, if blood glucose level <250 mg/dL
	IV $NaHCO_3$	May not work in patients on hemodialysis
		Effective if NaHCO3 <17, do not use if the patient is volume overloaded
	Inhaled albuterol	May not work in patients on hemodialysis
	Sodium polystyrene sulfonate	No role
	Patiromer, zirconium	No data

ECG: electrocardiography; IV: intravenous; VT: ventricular tachycardia

Table 2. Management of anticoagulants, antiplatelet drugs and bleeding diathesis

Condition	Drug	Comment
Anticoagulants	Heparin	4-6 hours for clearance, reversal with protamine possible if needed
	LMWH	Best avoid, reduce dose and monitor with anti-Xa if used, reversal with protamine is partial, unpredictable
	Warfarin	Discontinue until INR<1.1, requires heparin bridge
	Dabigatran, rivaroxaban, edoxaban	Avoid in ESRD, insufficient data
	Fondaparinux	Not approved in ESRD, anecdotal data suggests safety
	Apixaban	FDA approved
		Use of lower dose (2x2.5 mg) advocated in ESRD
		Discontinue 72-96 h before surgery, not dialyzable
		No bridging necessary
		Recently introduced “andexanet alpha” is the antidote to apixaban and rivaroxaban, may not be readily available
Antiplatelet drugs	Acetylsalicylic acid	Discontinue if high bleeding risk, 6-7 d before
	Clopidogrel	Discontinue if high bleeding risk, 5 d before
	Prasugrel, ticagrelor	Avoid in ESRD, insufficient data
Bleeding diathesis	Desmopressin	IV or intranasal, tachyphylaxis at 2^{nd} or 3^{rd} dose, may worsen HF
	Cryoprecipitate	Emergency, duration of action 8-24 h
	Conjugated estrogens	Used for prolonged, uncontrollable bleeding, uncertain risk of thrombosis, ancient data
	Tranexamic acid	Used in cardiovascular surgery, accumulates in ESRD
	Platelet transfusions	Only used in life threating bleedings

LMWH: low molecular weight heparin; INR: international normalized ratio; ESRD: end-stage renal disease; FDA: Food and Drug Administration; HF: heart failure

Table 3. Frequently used anesthetics and neuromuscular blockers and their renal considerations

Issue	Drug	Comment
Anesthetics	Propofol	Safe, beware of hypotension
	Nitrous oxide (N_2O)	Safe
	Midazolam	Partially dialyzable, beware of hypotension
	Ketamine	Safe
	Desflurane, isoflurane	Safe
	Sevoflurane	Most likely safe, theoretical nephrotoxicity not observed in vivo
Neuromuscular blockers	Succinylcholine	Avoid if K+ >5.5 mEq/L or ECG changes
		Causes K+ surge of 0.5-1 mEq/L, otherwise safe
	Atra or cis-atracurium	Safe, nonrenal elimination, short half-life
	Mivacurium	Curarization may be prolonged
	Vecuronium	Curarization may be prolonged
	Rocuronium	Curarization may be prolonged, effects are reversible with the antidote (sugammadex), drug-antidote complex is dialyzable
	Pancuronium	Avoid, curarization may be prolonged significantly
	Neostigmine	Safe, a single dose is as effective as that in healthy subjects

ECG: electrocardiography

Table 4. Common drugs used in analgesia and their renal considerations

Issue	Drug	Comment
Analgesics	Acetaminophen	Safe
	NSAIDs	Best to avoid, lowest dose, shortest duration possible
		May increase the cardiovascular risk even with minimal exposure
		May warrant gastrointestinal prophylaxis
Opiates	Codeine, meperidine	Avoid at all costs
	Oxycodone, tramadol	Best to avoid, when used longer intervals and dose reduction necessary, dialyzability unknown
	Morphine, hydromorphone	Use with great caution, longer intervals and dose reduction are necessary, dialyzable
	Fentanyl, alfentanyl	Safe with dose reduction, not dialyzable
	Remifentanil	Safe
	Methadone	Safe

NSAIDs: nonsteroidal anti-inflammatory drugs

the surgery to maintain hemoglobin levels of 11-12 g/dL reduces the need for transfusions. Instead of predefined hemoglobin thresholds, an individualized approach is more convenient.

Pain Palliation

Perioperative pain management in patients on hemodialysis is complex. Nonsteroidal anti-inflammatory agents need to be

used very cautiously. Most opiate analgesics have nephrologic issues to be considered for safe and successful analgesia. These issues are outlined in Table 4.

Glucose

Perioperative glucose levels should be kept under 180 mg/dL while refraining from hypoglycemia (1). However, there is no evidence on the benefits of a tighter glycemic control (13). Nevertheless, achieving hemoglobin A1c levels of 7%-8% may be reasonable before elective procedures.

Special Considerations

Routine hemodialysis before cadaveric transplantation is not mandatory. A case-by-case decision must be made, concerning the abovementioned points. The ultrafiltration rate is generally reduced by 500-1,000 mL in the last session before transplantation to prevent intraoperative hypotension and delayed graft function (11).

Patients with parathyroid hormone >1,000 pg/mL are at an increased risk for "hungry bone syndrome" after parathyroidectomy (14). Higher doses of vitamin D analogs a week before surgery and immediate calcium infusions after gland removal decrease the risk of symptomatic hypocalcemia. High-calcium bath dialysis is another short-term yet effective option.

Intraoperative dialysis is not routinely needed. Some centers perform CRRT during liver transplantation and cardiovascular procedures (15).

CONCLUSION

Management of patients on hemodialysis throughout surgery is a complex multidisciplinary task with a myriad of aspects to consider. Thus, nephrologists should be familiar with the basic yet critical principles covered in this article because they have a pivotal role in achieving successful outcomes.

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