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Local, regional, or general; a narrative review of anesthesia modalities for hemodialysis catheter placement

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ABSTRACT

Hemodialysis catheter placement is a critical procedure for patients with end-stage renal disease, often performed under varying anesthesia modalities depending on clinical context, patient comorbidities, and institutional protocols. This narrative review explores the comparative use of local, regional, and general anesthesia in the placement of tunneled and non-tunneled hemodialysis catheters. Drawing on studies indexed in reputable databases, we evaluated the efficacy, safety, procedural success, and patient-centered outcomes associated with each technique. Special attention is given to high-risk populations, including the elderly, pediatric patients, and those in critical care settings. Our findings suggest that while local anesthesia remains the most commonly used and resource-efficient approach, regional and general anesthesia may offer advantages in select populations, particularly where patient cooperation or procedural complexity is a concern. The review highlights the need for individualized anesthesia planning and calls for further prospective studies to establish evidence-based guidelines.

Keywords: Hemodialysis catheter, Central venous catheter, Anesthesia modalities, Local anesthesia, Regional anesthesia, General anesthesia, Vascular access, Catheter placement, Ultrasound-guided anesthesia

Implication for health policy/practice/research/medical education:

In this review study, we found that the choice of anesthesia for hemodialysis catheter placement should be individualized. Local anesthesia with sedation remains appropriate and efficient for most elective, cooperative patients due to its safety, rapid recovery, and resource advantages, while regional blocks provide superior analgesia and tolerance for patients with high anxiety, difficult anatomy, or when longer or more complex tunneling is required; general anesthesia is reserved for uncooperative patients, children, or when concurrent procedures mandate airway control. Clinically, practitioners should assess patient comorbidity, coagulation status, procedural complexity, and institutional resources, apply ultrasound guidance to optimize block success and reduce complications, and document anesthesia choice in a standardized protocol to improve patient comfort, procedural success, and throughput.

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Introduction

Hemodialysis remains a cornerstone of renal replacement therapy for millions of patients with end-stage kidney disease (ESKD) worldwide; establishing and maintaining reliable vascular access, including tunneled or non-tunneled central venous catheters (CVCs), is essential for effective hemodialysis therapy (1,2). The technique of catheter placement, as well as the choice of anesthesia modality, plays a critical role in procedural safety, patient comfort, and clinical outcomes (3). Anesthesia options for

hemodialysis catheter placement range broadly, from local infiltration anesthesia with or without sedation to regional anesthetic techniques (notably, various brachial plexus blocks or infiltration blocks), and, in selected scenarios, general anesthesia (4,5). Each anesthetic approach harbors specific advantages and drawbacks, with their applicability modulated by patient factors such as age, comorbidities, urgency, anatomical considerations, and previous access history. Despite the frequency of hemodialysis catheter placement, the optimal anesthesia approach remains

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debated and subject to institutional preference, operator expertise, and evolving guidelines (6). Recent advances in vascular access techniques, ultrasound-guided regional anesthesia, greater awareness of patient satisfaction, and changes in the dialysis population (with more elderly, comorbid, or critically ill patients) have provided new insights and challenges (7). Further complicating practice, there is a growing pediatric and adolescent dialysis population, whose distinct physiological, psychological, and anesthetic needs diverge significantly from adults (8). The objective of this narrative review is to synthesize, appraise, and contextualize the current literature regarding anesthesia modalities for hemodialysis catheter placement. This review was drawn from valid databases-indexed studies and reviews, integrating clinical trial evidence, observational studies, meta-analyses, systematic review studies, and guideline statements. Highlighted are key considerations for adult, pediatric, elderly, and critically ill populations, with additional attention to pharmacological issues, cost-effectiveness, and technology-enabled advances such as ultrasound guidance.

Search strategy and selection criteria

This narrative review is based on an extensive literature search of the PubMed, Web of Science, Scopus, DOAJ (Directory of Open Access Journals), and CINAHL (Cumulative Index to Nursing and Allied Health Literature) databases, as well as Google Scholar search engine. The search period includes up to the end of November 2025. The search strategy incorporated the following keywords, utilized both individually and in various Boolean combinations: “hemodialysis catheter,” “central venous catheter,” “anesthesia,” “local anesthesia,” “regional anesthesia,” “general anesthesia,” “vascular access,” “catheter placement,” “ultrasound-guided anesthesia,” “patient outcomes,” “elderly,” “pediatric,” “cost-effectiveness,” “safety,” and “guidelines.”

Inclusion criteria were original research articles (randomized trials and observational studies), meta-analyses, or comprehensive reviews addressing anesthesia methods for hemodialysis catheter placement. Studies reporting on adult, elderly, pediatric, or critically ill populations, and papers published in English. Studies selection favored studies with comparative analyses of anesthesia techniques or those discussing patient-specific considerations, efficacy, complications, patient satisfaction, or cost/resource utilization, and guidelines from reputable nephrology, anesthesiology, and vascular access societies were included.

Anesthesia methods for hemodialysis catheter placement

Local anesthesia

Local infiltration anesthesia typically involves subcutaneous or deeper infiltration of a local anesthetic agent at the planned vascular access site. Lidocaine,

mepivacaine, or prilocaine are most frequently employed for their rapid onset and favorable safety profiles. Local anesthesia is a mainstay for short procedures and is often considered the first-line choice for both temporary and tunneled catheter insertion (9).

Advantages

- **Simplicity and speed:** Local infiltration is technically straightforward, rapid to administer, and avoids the need for specialized anesthetic equipment (5).
- **Hemodynamic stability:** Profound systemic effects are rare, making local anesthesia often the safest option for patients with significant cardiovascular compromise (5).
- **Minimal sedation requirement:** local anesthesia may be combined with light sedation or anxiolysis on an as-needed basis, facilitating patient tolerance while maintaining airway reflexes (5).
- **Reduced risk profile:** Avoids risks associated with deep sedation/general anesthesia such as aspiration, prolonged sedation, and complex airway management (10).
- **Cost-effectiveness:** local anesthesia is resource-efficient and minimizes procedure- and facility-associated expense (10).

Limitations

- **Variable analgesia:** In some patients, especially with extensive tunneling or deep tissue manipulation, local anesthesia alone may provide insufficient pain control, resulting in discomfort, agitation, or procedural interruption (5).
- **No vasodilatory effect:** Unlike some regional techniques, local anesthesia does not facilitate vasodilation or increased blood flow at the access site, which may marginally decrease procedural success for difficult access sites (5,11).
- **Toxicity concerns:** Particularly in renal failure, there is a theoretical risk of local anesthetic systemic toxicity, though rarely observed with careful dosing and avoidance of high plasma concentrations (5).

Regional anesthesia

Regional anesthesia for hemodialysis vascular access most commonly refers to brachial plexus blockade, delivered via supraclavicular, infraclavicular, axillary, or interscalene approaches, and, less commonly, neuraxial blocks. The primary target is dense perineural blockade of the sensory and motor fibers supplying the upper extremity, rendering the operative field anesthetized (11-13). For lower body or abdominal procedures (e.g., peritoneal dialysis catheter placement), transversus abdominis plane blocks or neuraxial anesthesia have demonstrated efficacy, with added advantages of reduced perioperative opioid requirements and improved recovery profiles (9,14).

Advantages

- Superior analgesia: Regional anesthesia techniques confer profound sensory and motor blockade, providing optimal analgesia throughout the procedure and postoperatively (5,15).
- Vasodilation and increased blood flow: By inducing a sympathetic block, regional anesthesia can facilitate venous and arterial dilation, resulting in improved blood flow intra- and post-procedure. This is particularly beneficial for arteriovenous fistula (AVF) creation, but may also favor catheter placement in challenging anatomy (11).
- Enhanced procedural success: Augmented local blood flow, improved venous compliance, and patient immobility contribute to increased first-attempt success and lower risk of vascular spasm or thrombosis (5, 11).
- Patient satisfaction: Numerous studies and meta-analyses report high satisfaction, with improved pain scores compared to local anesthesia or general anesthesia, and decreased need for rescue analgesia (12, 15).

Limitations

- Operator dependence: High-quality regional anesthesia is reliant on anesthesiologist expertise, especially in ultrasound-guided nerve localization and block performance; novice operators may experience higher failure or complication rates (12).
- Complications: Risks include nerve injury, hematoma, infection, phrenic nerve palsy (notably with supraclavicular/inter-scalene blocks), and rare systemic toxicity. Hemidiaphragm paralysis may not be tolerated in patients with respiratory compromise (12).
- Prolonged recovery: Some blocks may persist for hours after the procedure, potentially delaying the return of motor function (16).
- Not suitable for coagulopathy: Relative contraindication in patients with significant bleeding diatheses or those on antiplatelet/anticoagulant therapy due to risk of compressive hematoma (16).

General anesthesia

General anesthesia offers complete unconsciousness, airway control, and immobility. While largely reserved for complex procedures, uncooperative patients, children, or cases where other modalities have failed or are contraindicated, it is still applied in select centers, particularly in pediatric settings or for extensive access revision/replacement (14,16,17).

Advantages

- Complete anesthesia: Ensures absence of pain, anxiety, and recall, facilitating lengthy or technically demanding procedures (17).

- Ideal for non-cooperative patients: Children or adults with psychological or cognitive barriers to cooperation may require general anesthesia (17).

Limitations

- Hemodynamic instability: Patients with ESKD frequently harbor cardiovascular comorbidities, and general anesthesia carries a substantially higher risk of intraoperative hypotension, arrhythmia, and other hemodynamic perturbations (18).
- Respiratory risks: Sensitivity to sedatives, muscle relaxants, and inhalational agents is increased. Volume overload, metabolic acidosis, and fluid shifts can precipitate hypoxemia or prolonged weaning from ventilation (19).
- Reduced recovery profile: Return to consciousness may be delayed compared to local anesthesia/regional anesthesia; there is also an increased incidence of postoperative nausea, vomiting, and delirium (19,20).
- Resource-intensive/more expensive: General anesthesia requires more extensive perioperative monitoring, recovery resources, and is associated with higher costs (21).

Comparative outcomes of anesthesia modalities

Procedural success and catheter function

Procedural success, measured by first-pass cannulation, correct tip position, and immediate catheter functionality, is influenced by both patient and operator factors, but anesthesia choice exerts a significant effect. Evidence demonstrates:

- Local anesthesia: Yields high rates of procedural success for both temporary and tunneled catheter insertion, especially when performed by skilled operators with ultrasound guidance. Failures are typically related to patient discomfort, anxiety, or technical challenges rather than the anesthesia method itself (22,23).
- Regional anesthesia: Data from previous studies consistently show that regional anesthesia, particularly brachial plexus block, increases regional blood flow and vessel diameter, facilitating easier cannulation and reduced rates of vasospasm or thrombosis. Meta-analyses confirm that regional anesthesia is associated with higher primary patency and immediate blood flow compared to local anesthesia; although this effect is less pronounced for simple catheterization, enhanced vessel compliance may benefit certain patients (e.g., small caliber veins, prior access failure) (5, 11,13).
- General anesthesia: general anesthesia neither impairs nor augments procedural success, provided airway and hemodynamics are well-managed. However, it is associated with longer periprocedural times (induction, emergence), higher cost, and greater care complexity, with documented increases

in hemodynamic instability and hypotension (14,17).

Complications and safety

Immediate/procedural complications

- Local anesthesia: Risks are minimal. The chief concerns are discomfort, inadequate block, and rare instances of local anesthetic systemic toxicity, especially with inadvertent intravascular injection or overdose. Allergic reactions, methemoglobinemia (especially with prilocaine), and vasovagal reactions are uncommon but possible (24).
- Regional anesthesia: In addition to local anesthesia risks, regional anesthesia introduces potential for inadvertent nerve injury (transient or permanent), hematoma (especially in patients with coagulopathy), phrenic nerve palsy (notably with supraclavicular/inter-scalene blocks), and local anesthetic systemic toxicity. Modern ultrasound-guided regional anesthesia has dramatically reduced severe complications; reported rates of pneumothorax, hemidiaphragm paralysis, and nerve injury are <1% in expert hands (25,26).
- General anesthesia: general anesthesia exposes patients to a higher risk of airway compromise, aspiration, hypotension, arrhythmia, and, in rare cases, cardiac arrest. Patients with severe left ventricular dysfunction, pulmonary disease, or anemia are at heightened risk (18).

Delayed/post-procedural complications

- Infection: Catheter-related bloodstream infections are a risk inherent to catheterization rather than the anesthesia type, but prolonged procedures (potentially more common under general anesthesia or regional anesthesia) and breaks in aseptic techniques may increase risk (25,27,28).
- Hematoma and bleeding: Coagulopathy is a notable risk in chronic kidney disease and ESKD populations. Both local anesthesia and regional anesthesia may be complicated by bleeding at the access site; regional anesthesia is relatively contraindicated with significant bleeding diathesis (16).
- Neurological deficits: Rare and almost entirely limited to regional anesthesia; most reported nerve injuries are transient. Block-specific complications (Horner's syndrome for supraclavicular blocks) are well-documented but typically resolve spontaneously (12,26).

Patient satisfaction and analgesic quality

- Local anesthesia plus minimal sedation yields high satisfaction for most patients, provided the anesthesia is sufficient and the practitioner is attentive to anxiety/distress (29).
- Regional anesthesia provides excellent analgesia: Randomized trials and observational studies show

lower intraoperative and postoperative pain scores, less need for rescue medication, enhanced comfort during the procedure, and faster return to oral intake/ambulation compared to local anesthesia or general anesthesia (12,15,26).

- General anesthesia is generally well-tolerated among cooperative adults but may be preferred in certain subgroups: For example, pediatric or very anxious patients often demonstrate higher satisfaction with general anesthesia, as it guarantees the absence of awareness or pain (13).

Patient considerations

Pediatric patients

Catheter placement and anesthesia

- Tunneled CVCs are frequently required, particularly in infants and young children who are not yet candidates for AVF and arteriovenous graft (AVG) (17).
- General anesthesia is often required to ensure immobility and emotional safety during placement, especially in younger or less cooperative patients (17).
- Risk of airway and hemodynamic instability is increased; perioperative care staff with pediatric expertise are required (17).
- Regional anesthesia (e.g., brachial plexus block) may be feasible for older children, but technical limitations and lack of standardization hinder broad implementation (17).

Catheter size and technical feasibility

Choice of catheter size is closely tailored to the child's size and vasculature. Commercially available pre-curved catheters may not be suitable. Formulas and intraoperative imaging are employed for optimal selection (17,30).

Complications and outcomes

Central venous catheters are associated with higher rates of infection, central venous stenosis, and hospitalization than AVF/AVG; creation of fistulae/grfts is preferable when possible, but limitations exist based on body size, vessel caliber, and growth potential (31).

Patient experience

Catheter placement and repeated cannulations can be traumatic without adequate sedation/anesthesia. Robust psychosocial support and family involvement are recommended (30,31).

Elderly patients

- Comorbidities: Higher prevalence of cardiovascular, cerebrovascular, and pulmonary disease increases the risks associated with both regional anesthesia and general anesthesia (16,25).
- Anesthesia decision-making: local anesthesia is often sufficient for catheter placement and is preferred

for minimizing systemic effects, though select patients may still benefit from regional anesthesia for improved analgesia or when extensive tunneling is required (25).

- Functionality and satisfaction: Surveys reveal that elderly patients may value functional, low-intervention access options (including tunneled CVCs) over more durable AVF/AVG, especially when life expectancy is limited or patency rates are poor (25).

Critically ill patients

- Anesthesia choices: local anesthesia is preferred due to high cardiorespiratory instability and difficulties with airway management typical of this population (16).
- Sedation management and venous access: Careful titration of sedatives is essential; uremia, sepsis, and polypharmacy alter anesthetic sensitivity. Femoral vein access may be chosen for expediency in the critically ill; however, it increases infection risk compared to jugular vein placement. Ultrasound guidance is mandatory to optimize success and minimize mechanical complications (22,23,32).

Guidelines and protocols

Vascular access choice

- AVF remains the gold standard for durable access but is often not suitable at dialysis initiation, necessitating initial CVC placement in many patients (25,28).
- Guidelines emphasize the importance of patient-centered care, informed consent, and the need to balance risk, functionality, and lifespan for access choice (25).

Anesthesia recommendation

- Adults: local anesthesia or regional anesthesia are recommended for AVF/AVG creation and are favored over general anesthesia, especially in the elderly or those with significant comorbidities. Catheter insertion generally does not require general anesthesia (22,23,25).
- Children: general anesthesia is suggested as standard, sometimes supplemented by regional anesthesia/local anesthesia for postoperative analgesia (22,23,25).
- Ultrasound guidance: Strongly recommended for vascular access (both for needle cannulation and for anesthetic block guidance) to increase success, minimize attempts, and prevent complications (22,23,25).

Aseptic technique and infection prevention

Access by trained personnel, protocolized aseptic handling, site inspection at each session, and regular disinfection (chlorhexidine-based solutions recommended) are viewed as mandatory to reduce catheter-related infections (25,27).

Cost-effectiveness and resource use

- Local anesthesia and regional anesthesia are cost-effective compared to general anesthesia, with local anesthesia typically the least expensive option across global settings (10,33).
- Temporary catheters are less costly per day of use but more likely to require replacement, have higher infection rates, and are often less durable than tunneled catheters (10,33).

Conclusion

The optimal anesthetic approach for hemodialysis catheter placement depends upon patient- and procedure-specific factors. Local anesthesia remains the standard of care for most adult and elderly patients undergoing routine vascular catheter placement, balancing procedural efficacy, safety, patient comfort, and cost-effectiveness. Regional anesthesia, delivered via brachial plexus block or other targeted techniques, offers superior analgesia and improved vessel conditions but requires specialist expertise and is best reserved for more complex procedures, challenging anatomy, or when local anesthesia alone is inadequate. General anesthesia is generally reserved for pediatric patients, non-cooperative individuals, or highly complex situations due to increased risk of systemic complications, although it remains indispensable in pediatric vascular access surgery. Furthermore, across all modalities, adherence to aseptic protocols, rigorous patient assessment, skill retraining, and, critically, the use of ultrasound guidance are paramount in minimizing complications and optimizing outcomes. Patient preference, satisfaction, and quality-of-life impact should inform decision-making, alongside consideration of resource utilization and institutional capabilities. Recent guideline updates support a flexible, individualized approach that weighs technical success, safety, and person-centered outcomes in this expanding and medically complex population. Collectively, there is no superior anesthesia modality for all cases of hemodialysis catheter placement. Local anesthesia is effective for most adults; regional anesthesia confers optimal analgesia and procedural conditions when expertise exists, with ultrasound guidance enhancing both success and safety across techniques. General anesthesia retains a role in the pediatric and select adult populations. Ongoing research, quality improvement, and guideline refinement are essential to further harmonize safety, patient experience, and resource stewardship in vascular access anesthesia.

Authors' contribution

Conceptualization: Bahador Oshidari and Malihe Abniki

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Visualization: Bahador Oshidari.

Writing–original draft: All authors.

Writing–review and editing: All authors.

Conflicts of interest

The authors declare that they have no competing interests.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors utilized Copilot to refine grammar points and language style in writing. Subsequently, the authors thoroughly reviewed and edited the content as necessary, assuming full responsibility for the publication's content.

Ethical issues

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