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The Effectiveness of Nurse-Led Interventions in Preventing Intradialytic Hypotension Among Hemodialysis Patients

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ABSTRACT: Intradialytic hypotension (IDH) remains one of the most common and clinically significant complications of hemodialysis, affecting a substantial proportion of treatments and contributing to patient discomfort, shortened dialysis sessions, inadequate

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solute clearance, and increased risk of cardiovascular morbidity and mortality. Because IDH is multifactorial—arising from rapid ultrafiltration, impaired compensatory mechanisms, and individual patient characteristics—prevention depends on consistent, attentive bedside practices rather than a single pharmacological fix. Nurses are uniquely positioned to detect early warning signs, adjust procedural parameters, and educate patients, making nurse-led interventions a promising and resource-efficient strategy for reducing IDH incidence. Evidence from the literature suggests that structured nurse-led interventions can meaningfully reduce the frequency and severity of IDH. Such interventions typically include systematic pre-dialysis risk assessment, individualized ultrafiltration and sodium profiling, careful monitoring of blood pressure trends during treatment, proactive patient positioning, and tailored patient education on fluid and dietary management. Studies report that nurse-driven protocols—particularly those incorporating continuous blood pressure monitoring, reduced ultrafiltration rates, cooled dialysate, and early symptom recognition—are associated with fewer hypotensive episodes, improved treatment tolerance, and greater hemodynamic stability. However, the evidence base is constrained by heterogeneity in intervention design, small sample sizes, and variability in outcome definitions. Overall, nurse-led interventions appear effective and low-cost, but standardization and larger rigorous trials are needed to establish best-practice protocols.

INTRODUCTION

Intradialytic hypotension is the most frequent acute complication of maintenance haemodialysis, and its prevention has become a defining test of dialysis nursing practice. A recent systematic review and meta-analysis of nursing and non-pharmacological interventions concluded that although several strategies are biologically plausible and widely used, the pooled evidence remains limited and heterogeneous, with nurse-led interventions in particular failing to reach statistical significance for improvement in intradialytic systolic blood pressure [1]. This finding is not an argument against nursing intervention; it is an argument for examining more carefully what nurse-led prevention actually consists of, how it is implemented, and which outcomes are used to judge its success [1].The burden of the problem is substantial. Prevalence estimates vary according to definition and case mix, but intradialytic hypotension affects a large minority of treatments and is associated with symptoms, reduced dialysis adequacy, vascular access complications, and increased mortality [2]. Nurses are present throughout the treatment session and are responsible for repeated cardiovascular assessment, ultrafiltration monitoring, recognition of prodromal symptoms, and patient education; their knowledge and practice therefore directly shape the risk of hypotensive episodes [3]. Yet the translation of this proximal role into measurable patient benefit is not automatic. Frequent intradialytic hypotension has been associated with a significantly higher risk of death, including cardiovascular death, and with diabetes as an independent risk factor, which means that prevention is a mortality-relevant safety issue rather than a comfort measure alone [4]. The broader clinical literature similarly identifies intradialytic hypotension as a marker of poor outcomes and a target for systematic preventive care [5].

Pathophysiology of Intradialytic Hypotension

Intradialytic hypotension is not a single disease but a final common pathway arising from the interaction of ultrafiltration-induced intravascular volume depletion, impaired cardiovascular compensatory responses, and dialysate-related thermal and osmotic stresses [6]. During a standard haemodialysis session, fluid is removed from the intravascular compartment at a rate that frequently exceeds the rate of plasma refilling from the interstitial and intracellular spaces. When the discrepancy between the ultrafiltration rate and the plasma refill rate becomes critical, blood volume declines steeply and arterial pressure falls. In healthy individuals, this challenge is met by baroreceptor-mediated sympathetic activation, increased peripheral vascular resistance, venoconstriction, and tachycardia. In patients with chronic kidney disease, these compensatory mechanisms are frequently blunted by autonomic neuropathy, left ventricular hypertrophy and diastolic dysfunction, uraemic cardiomyopathy, and the effects of antihypertensive medications.

Dialysate temperature exerts a decisive influence on haemodynamic stability. Cool dialysate, typically 0.5–1.0°C below core body temperature, induces precapillary vasoconstriction, activates the sympathetic nervous system, preserves central blood volume, and thereby mitigates the fall in blood pressure [7]. Conversely, warmer dialysate promotes cutaneous vasodilation and reduces the capacity to defend mean arterial pressure during ultrafiltration. Sodium profiling—the programmed variation of

dialysate sodium concentration during the session—aims to support plasma osmolality and vascular refill early in treatment while avoiding excessive sodium loading, although its effectiveness is contingent on the specific profile used and remains a subject of debate [8]. Ultrafiltration profiling, in which the rate of fluid removal is varied across the session, has been proposed as a complementary strategy, but trial evidence suggests that it reduces light-headedness rather than the overall odds of intradialytic hypotension and does not consistently attenuate treatment-related cardiac stress [9].

The pathophysiology therefore identifies several modifiable leverage points: the rate and pattern of ultrafiltration, the thermal set-point of the dialysate, the sodium concentration and profile, the timing of food and antihypertensive medication, and the accuracy of the estimated dry weight. Each of these is amenable to nursing assessment and, within protocolised limits, nursing action. The critical question for nurse-led care is whether nurses can reliably identify which patients are at risk, select and titrate the appropriate combination of modifications, and recognise deterioration early enough to intervene before symptomatic hypotension becomes established.

Risk Factors and the Case for Stratified Nursing Surveillance

The risk of intradialytic hypotension is not uniformly distributed across the dialysis population. Older age, female sex, long dialysis vintage, diabetes mellitus, high interdialytic weight gain, low pre-dialysis blood pressure, anaemia, high body mass index, and the use of multiple antihypertensive agents have all been associated with increased frequency of hypotensive episodes [2]. These factors are not merely epidemiological curiosities; they are clinically observable before the patient sits in the chair. A nurse who systematically records interdialytic weight gain, reviews antihypertensive timing, and notes the pre-dialysis blood pressure is already performing a risk stratification that can inform the intensity of monitoring and the aggressiveness of preventive modification [4].

The consequences of failing to act on this risk profile are substantial. Frequent intradialytic hypotension is associated with a significantly higher risk of death; in a prospective cohort, a substantial proportion of patients died during the at-risk period, including cardiovascular deaths, and diabetes was an independent risk factor [10]. Intradialytic hypotensive episodes also compromise dialysis adequacy by forcing the reduction or interruption of ultrafiltration, predispose to arteriovenous fistula thrombosis, and contribute to cerebral hypoperfusion and cardiac stunning. Higher pre-dialytic serum phosphate has also been reported as a risk marker, and NT-proBNP has been investigated as a predictor of hypotensive episodes [11]. Diabetes mellitus, in particular, has emerged as an independent risk factor for intradialytic hypotension, reflecting the combined effects of autonomic neuropathy and cardiovascular comorbidity [12]. The nursing implication is that intradialytic hypotension prevention is not simply a comfort measure but a mortality-relevant safety intervention. This recognition has driven the development of structured nursing protocols and decision algorithms for ultrafiltration management and the recognition, management, and documentation of intradialytic hypotension in both in-centre and acute dialysis settings.

Table 1 summarises the principal risk factors for intradialytic hypotension and the corresponding nursing assessment actions that can be incorporated into a pre-dialysis safety checklist.

Risk factor	**Nursing assessment action before or during dialysis**
Advanced age and female sex	Flag as higher-risk; increase frequency of intradialytic blood pressure measurement
Long dialysis vintage	Review historical intradialytic hypotension pattern; consider lower initial ultrafiltration rate
Diabetes mellitus and autonomic neuropathy	Assess orthostatic symptoms; avoid rapid ultrafiltration early in session
High interdialytic weight gain	Calculate percentage weight gain; discuss fluid and sodium intake; consider ultrafiltration profiling
Low pre-dialysis blood pressure	Review antihypertensive timing; consider withholding per prescription; initiate cool dialysate discussion
Multiple antihypertensive agents	Confirm which agents were taken and when; collaborate with prescriber on dialysis-day dosing

Anaemia and low haemoglobin	Verify recent haemoglobin; recognise reduced physiological reserve
High body mass index	Anticipate difficulties in dry weight estimation; use clinical volume assessment adjuncts

Nursing Assessment and Monitoring as the Foundation of Prevention

No preventive strategy can be effective if the patient's haemodynamic trajectory is not observed. The first and most fundamental nurse-led intervention is structured, protocolised monitoring. Best practice requires pre-dialysis blood pressure measurement in both arms where feasible, repeated intradialytic measurements at intervals of 30 to 60 minutes—and more frequently when symptoms emerge or when the patient is known to be hypotension-prone—and a post-dialysis assessment that includes orthostatic evaluation. The timing of measurement matters: intradialytic hypotension most commonly occurs in the latter part of the session when cumulative ultrafiltration has depleted intravascular volume, but individual patterns vary, and a patient who is stable at one hour may become symptomatic at two and a half hours. Nurses should therefore treat the blood pressure trend, not isolated readings, as the primary signal. The absence of a universally accepted definition has been a persistent obstacle to comparing intervention effects across studies, and nursing units that adopt a local operational definition are better positioned to evaluate their own practice [13].

Clinical signs and symptoms remain indispensable alongside numerical thresholds. A fall in systolic pressure accompanied by yawning, dizziness, sweating, nausea, abdominal discomfort, or cramping constitutes a prodromal syndrome that frequently precedes a formal hypotensive episode. Recognition of these early features allows the nurse to reduce the ultrafiltration rate, reposition the patient, and administer a small crystalloid bolus before the episode becomes severe. Advanced monitoring technologies can extend nursing surveillance. Blood volume monitoring and bioelectrical impedance assessment have been investigated as adjuncts to clinical volume assessment, although their incremental value over skilled clinical observation remains uncertain; a pilot implementation study of fluid volume assessment by dialysis nurses using clinical signs, symptoms, and bioelectrical impedance demonstrated the feasibility of incorporating such assessments into nursing workflow and measured safety outcomes including intradialytic hypotension [14]. The nurse-led decision algorithm for setting ultrafiltration targets in acute dialysis is a further example of how monitoring data can be converted into a structured action pathway rather than remaining as isolated observations, and the development of an RN-initiated protocol for recognition, management, and documentation of intradialytic hypotension illustrates how monitoring can be linked to accountable nursing action [15].

Table 2 presents a practical nursing monitoring schedule that can be adapted to unit resources and patient acuity.

Time point	Nursing observations and actions
Before cannulation	Bilateral blood pressure; heart rate; weight; temperature; review of symptoms since last session; fluid and sodium intake history
First 30 minutes	Blood pressure and heart rate; assessment of ultrafiltration rate against prescribed target; review of dialysate temperature and sodium settings
Every 30–60 minutes thereafter	Blood pressure and heart rate; symptom enquiry (dizziness, cramping, nausea, yawning); visual inspection of the extracorporeal circuit and access site
Any symptomatic change	Immediate blood pressure recheck; reduce or pause ultrafiltration; position patient supine with legs elevated; administer prescribed crystalloid if indicated; document event and response
End of session and post-dialysis	Post-dialysis blood pressure; orthostatic assessment; review of achieved ultrafiltration and dry weight; documentation of any intradialytic hypotension episode and its management

Dialysate Temperature Reduction: A Nurse-Activated Physiological Strategy

Cool dialysate is among the best-supported non-pharmacological interventions for intradialytic hypotension prevention. Systematic review evidence indicates that maintaining dialysate temperature between 34.5°C and 36.0°C reduces the incidence of intradialytic hypotension and may improve dialysis adequacy in chronic haemodialysis patients [16]. A reduction of as little as 0.5–1.0°C below core body temperature produces a significant effect on intradialytic hypotension in susceptible populations, and narrative reviews report consistent cardioprotective signals alongside improved haemodynamic stability [17]. The physiological mechanism—sympathetically mediated vasoconstriction and preservation of central blood volume—is well characterised, and the intervention is inexpensive and universally applicable [7].

The nurse-led dimension of temperature reduction lies in individualisation and activation. Fixed low-temperature prescriptions may be poorly tolerated by patients who feel cold, particularly in winter or in units with limited blanket supplies. A more sophisticated nursing approach is to set the dialysate temperature 0.5°C below the patient's measured core temperature, or to use a standard cool temperature as a default for patients with a documented history of recurrent intradialytic hypotension, while monitoring for shivering and discomfort. The nurse is also responsible for ensuring that the temperature reduction is documented as a therapeutic intervention rather than an incidental setting, and for evaluating whether it reduces episode frequency over successive sessions. In units where cool dialysate is used as a routine, the nurse's role shifts from activation to surveillance: confirming that the prescribed temperature is actually delivered, recognising patients who remain hypotensive despite cooling, and escalating to medical review when repeated episodes occur [17].

Sodium and Ultrafiltration Profiling: Protocolised Nursing Titration

Sodium profiling and ultrafiltration profiling represent a more technically complex frontier of nurse-led prevention. Sodium modelling modulates dialysate sodium concentration according to a pre-established profile, typically delivering higher sodium early in the session to support vascular refill and lower sodium later to avoid net sodium gain [8]. Clinical practice studies involving haemodialysis nurses have reported that sodium profiling can improve practice quality and reduce nursing workload in patients with intradialytic hypotension, and combination sodium–ultrafiltration profiling has been associated with fewer nursing interventions, less saline infusion, fewer reductions or interruptions of ultrafiltration, and fewer session failures [18]. The optimal strategy identified in one comparative study was combined linear sodium and ultrafiltration profiling, while a separate investigation recommended sodium profile plus ultrafiltration profile as a simple, cost-effective method for preserving haemodynamic status and reducing nursing work during dialysis [19].

The evidence is not uniformly positive. Ultrafiltration profiling alone did not reduce the odds of treatment-related cardiac stress in a pilot randomised crossover trial, although it did reduce light-headedness and post-dialysis hypervolemia [9]. Excessive sodium gain remains a legitimate concern with sodium profiling, and sodium-balance-neutral profiles combined with ultrafiltration profiling have been proposed as a safer alternative that avoids sodium accumulation while still reducing intradialytic hypotension-related discomfort [20]. For nursing practice, the implication is that profiling should not be applied indiscriminately. The nurse's role is to identify the patient with recurrent intradialytic hypotension despite standard cool dialysate and judicious ultrafiltration, to collaborate with the nephrologist in selecting a profile, to monitor the response across several sessions, and to document both hypotensive episodes and any evidence of sodium-related adverse effects such as excessive thirst or hypertension [20].

Table 3 compares the principal dialysate and ultrafiltration modifications available to nursing-led prevention, with their proposed mechanisms and the nursing actions required for safe implementation.

Modification	Mechanism	Nursing action
Cool dialysate (34.5–36.0°C or 0.5–1.0°C below core temperature)	Sympathetic activation, peripheral vasoconstriction, preservation of central blood volume	Set and verify temperature; monitor for shivering; document as therapeutic intervention
Sodium profiling	Supports plasma osmolality and vascular refill early; limits late-session decline	Confirm prescribed profile; monitor for excessive thirst, interdialytic weight gain, and hypertension
Ultrafiltration profiling	Matches fluid removal to plasma refill capacity across the session	Review profile against achieved ultrafiltration; assess for light-headedness and post-dialysis hypervolemia
Combined sodium and ultrafiltration profiling	Addresses both osmotic and volumetric determinants of refill	Coordinate with prescriber; audit episode frequency and nursing interventions over successive sessions

Patient Education and Shared Prevention

The interval between dialysis sessions is where the patient's fluid and sodium behaviour is determined, and it is therefore where much of the preventive work must be situated. Nurse-led education targeting sodium restriction, fluid management, recognition of early warning symptoms, and the importance of adhering to the prescribed dialysis schedule is a core component of

intradialytic hypotension prevention. The rationale is straightforward: excessive interdialytic weight gain necessitates higher ultrafiltration rates, which in turn increase the likelihood of a mismatch between fluid removal and plasma refill. By reducing sodium intake, the patient reduces thirst and thereby reduces the obligatory fluid gain that drives high ultrafiltration requirements.

The evidence for education as a stand-alone intervention is mixed. A study of fluid training for haemodialysis patients examined the effect of nutrition and fluid restriction training on interdialytic fluid intake and intradialytic hypotension, but the findings suggested that fluid restriction education alone may not be sufficient to reduce interdialytic fluid intake and intradialytic hypotension [21]. This is an important caution: education that merely instructs patients to "drink less" is unlikely to succeed if it does not address the sodium-driven thirst that makes fluid restriction so difficult. Effective education is behavioural and practical. It helps patients identify hidden sources of sodium, plan meals and fluid intake around dialysis days, recognise the early symptoms of hypotension, and understand why reporting those symptoms to the nurse during the session is important [3].

A quasi-experimental study of an educational intervention for dialysis nurses demonstrated that structured training significantly improved both knowledge and practice scores in the prevention and management of intradialytic hypotension, with mean knowledge rising from 5.3 to 13.1 and mean practice from 12 to 20 [22]. This finding is important because it establishes that the nurse's own knowledge base is modifiable and that education can change observable practice. It also underscores a limitation: improved knowledge and practice scores do not automatically translate into reduced patient-level intradialytic hypotension events. The chain from nurse education to patient education to behavioural change to haemodynamic outcome is long, and each link requires reinforcement [22].

Structured Protocols, Algorithms, and Quality Improvement

The effectiveness of individual nurse-led interventions depends heavily on the organisational context in which they are delivered. An isolated cool-dialysate order or a single education session is unlikely to change outcomes; a protocolised system that standardises assessment, triggers action at defined thresholds, and audits results is more likely to produce sustained benefit. The development of an RN-initiated protocol for the recognition, management, and documentation of intradialytic hypotension in patients with end-stage kidney disease on in-centre haemodialysis is a direct example of nursing translating evidence into accountable practice [15]. Similarly, a nurse-led decision algorithm for ultrafiltration target setting in acute dialysis has been described as a scalable protocol that promotes patient safety and workflow efficiency [23].

Quality improvement methodology provides the framework for implementing and evaluating such protocols. A typical cycle begins with baseline measurement of intradialytic hypotension frequency, documentation completeness, and the proportion of sessions in which ultrafiltration was interrupted. The protocol is then introduced with staff education, and the same measures are re-audited. The educational intervention study cited above used a pre–post design with knowledge and practice scores as intermediate outcomes [22]; a more mature quality improvement programme would add patient-level outcomes such as symptomatic episode rate, session completion, and dialysis adequacy [24]. The systematic review evidence that nurse-led interventions did not achieve statistical significance for systolic blood pressure improvement should be read in this light: the absence of a pooled statistically significant effect across heterogeneous studies does not mean that protocolised nursing care is ineffective, but rather that the intervention components, populations, and outcome measures have been too varied to yield a precise pooled estimate [1]. The review authors themselves conclude that nurse-led care and technology-based approaches are likely complementary and that further well-designed studies with patient-centred outcomes are needed [1].

Table 4 outlines a quality improvement framework for a nurse-led intradialytic hypotension prevention programme, linking structure, process, and outcome measures.

Domain	Example measure	Data source
Structure	Proportion of nursing staff trained in intradialytic hypotension recognition and protocol use	Training records
Structure	Availability of a written nurse-initiated intradialytic hypotension protocol and cool-dialysate guideline	Unit policy inventory
Process	Proportion of sessions with blood pressure recorded at least every 60 minutes	Dialysis flow sheets

Process	Proportion of intradialytic hypotension episodes with documented nursing action and response	Incident and progress notes
Process	Proportion of eligible patients receiving cool dialysate or profiling	Dialysis prescription audit
Outcome	Symptomatic intradialytic hypotension episodes per 100 patient-sessions	Incident reporting and session records
Outcome	Proportion of sessions with unplanned ultrafiltration reduction or early termination	Dialysis records
Outcome	Patient-reported symptom burden and dialysis adequacy (Kt/V)	Patient survey and laboratory data

Synthesis: What Nurse-Led Interventions Can and Cannot Achieve

The evidence reviewed here supports a nuanced conclusion. Nurse-led interventions are biologically plausible, practically feasible, and in many units already embedded in routine care. Cool dialysate, structured monitoring, early recognition and response, ultrafiltration adjustment, sodium and ultrafiltration profiling under protocol, and patient education all address legitimate pathophysiological targets [1]. Observational and quasi-experimental data show that nurses can be trained to deliver these interventions with improved knowledge and practice scores, and that protocolised nursing care can reduce the nursing workload associated with hypotensive episodes [18]. The systematic review evidence, however, does not demonstrate a statistically significant pooled effect of nurse-led interventions on systolic blood pressure, and the certainty of that evidence is very low [1]. This does not justify nihilism; it justifies methodological rigour.

Several explanations for the gap between plausibility and proof are apparent. First, the interventions studied under the "nurse-led" label are heterogeneous: a trial of intermittent pneumatic compression delivered by nurses is not conceptually equivalent to a trial of nurse-led sodium profiling or a trial of nurse-delivered education. Second, outcome definitions vary widely, and many studies use surrogate haemodynamic endpoints rather than clinically meaningful intradialytic hypotension episodes [13]. Third, nurse-led interventions are often implemented in combination with technological or prescriber-driven changes, making it difficult to isolate the nursing contribution. Fourth, the populations studied are often small, single-centre, and selected for hypotension proneness, limiting generalisability. Finally, the effectiveness of a nurse-led intervention depends on the fidelity with which it is delivered; a protocol that is not consistently followed cannot be expected to produce a consistent effect [24].

The most defensible position, therefore, is that nurse-led interventions should be understood as a system rather than a list of discrete tasks. The system comprises risk stratification before dialysis, protocolised monitoring during dialysis, a defined set of nurse-activated responses to early haemodynamic deterioration, individualised dialysate and ultrafiltration prescription within nursing scope, structured patient education, and audit and feedback [15]. The effectiveness of the system as a whole is likely to exceed the effectiveness of any single component, and future research should evaluate bundled nurse-led protocols using patient-centred outcomes and adequate follow-up [25]. In particular, studies should report symptomatic episodes, session completion, dialysis adequacy, and patient-reported outcomes rather than relying exclusively on intermediate haemodynamic measures.

CONCLUSION

Intradialytic hypotension remains a common, consequential, and partially preventable complication of haemodialysis. Nurse-led interventions address the points in the treatment pathway where prevention is most feasible: the pre-dialysis risk assessment, the intradialytic monitoring and early response, the dialysate and ultrafiltration prescription, and the interdialytic education that shapes patient behaviour. The evidence for any single intervention is modest and heterogeneous, and the pooled effect of nurse-led strategies on systolic blood pressure has not reached statistical significance in systematic review. Nevertheless, the absence of definitive trial evidence should not obscure the fact that structured nursing surveillance, cool dialysate, protocolised ultrafiltration and sodium management, and practical patient education are low-risk, physiologically rational, and consistent with the professional scope of dialysis nursing. The priority for the field is to move from isolated interventions to evaluated nurse-led systems, with uniform definitions, patient-centred outcomes, and quality improvement infrastructure that makes the effect of nursing visible and accountable. In that transition, the dialysis nurse is not merely the deliverer of a prescription but

the clinician who identifies the patient at risk, interprets the trend before the crisis, acts within protocol, and teaches the patient to participate in prevention. That is the essence of nurse-led care, and it is where the most durable gains are likely to be found.

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