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ORIGINAL RESEARCH

Clinical Efficacy of Levocarnitine-Alprostadil Combination Therapy on Indicators of Renal Function, Oxidant-Antioxidant Balance, and Systemic Inflammation in Patients with End-Stage Diabetic Nephropathy

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Objective: To investigate the effects of combined Levocarnitine and Alprostadil therapy on renal function, oxidant-antioxidant balance, and systemic inflammation in patients with end-stage diabetic nephropathy (ESDN).

Methods: This retrospective study included 104 ESDN patients admitted to our hospital between April 2021 and April 2023 who met all inclusion criteria. All patients were on maintenance hemodialysis for chronic kidney failure due to ESDN. Based on the treatment regimen received, patients were divided into two groups: the control (n=51) received intravenous Alprostadil (20 μg/day) for 30 days in addition to standard care, and the observation group (n=53) received additional intravenous Levocarnitine (1.0 g/day) for 30 days. Clinical efficacy, renal function parameters [blood urea nitrogen (BUN), cystatin C (Cys-C), 24-hour urinary protein (24 h Upro)], oxidative stress markers [malondialdehyde (MDA), superoxide dismutase (SOD), reactive oxygen species (ROS)], inflammatory factors [C-reactive protein (CRP), interleukin-1β (IL-1β), interleukin-6 (IL-6)], and adverse reactions were compared between groups.

Results: The cumulative treatment effectiveness (defined as the sum of patients with "markedly effective" and "effective" outcomes) was significantly higher in the observation group (92.45%) compared to the control group (78.43%, $P<0.05$). Post-treatment, the observation group demonstrated significantly greater improvements in all parameters: lower BUN (4.35±1.06 vs 5.29±1.12 mmol/L), Cys-C (1.21±0.34 vs 1.75±0.46 mg/L), 24 h Upro (66.79±18.37 vs 75.17±19.54 mg/24h), MDA (3.54±0.89 vs 4.63±1.08 nmol/mL), ROS (371.34±46.32 vs 417.53±48.16 U/mL), CRP (5.02±0.83 vs 6.63±0.94 mg/L), IL-1β (11.04±2.38 vs 13.61±2.67 pg/mL), and IL-6 (12.78±3.51 vs 16.84±4.53 pg/mL), alongside higher SOD (88.17±9.34 vs 72.49±8.71 U/mL) ($P<0.05$). Adverse reaction incidence showed no significant difference (16.98% vs 13.73%, $P>0.05$).

Conclusion: In ESDN patients, the combination of Levocarnitine and Alprostadil demonstrates superior cumulative treatment effectiveness over Alprostadil monotherapy in improving renal function, reducing oxidative stress, and attenuating inflammation, without increasing the incidence of adverse reactions.

Keywords: end-stage diabetic nephropathy, levocarnitine, alprostadil, renal function, oxidative stress, inflammatory response

Introduction

Diabetic nephropathy (DN) is a major microvascular complication of diabetes and one of the leading causes of end-stage renal disease (ESRD) worldwide.[1] In many regions, end-stage diabetic nephropathy (ESDN) accounts for a substantial proportion of ESRD cases and ranks second only to glomerulonephritis.[2] With the global rise in diabetes prevalence, the burden of ESDN continues to increase, contributing significantly to morbidity, cardiovascular complications, and mortality.[3] Patients with ESDN often present with a rapid deterioration in renal function, resulting in oliguria or anuria

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and the subsequent need for renal replacement therapies such as hemodialysis or peritoneal dialysis.[4] The pathogenesis of DN involves complex and interconnected mechanisms, including glomerular endothelial injury, tubular dysfunction, apoptosis, fibrosis, oxidative stress, and chronic inflammation.[5]

Although dialysis remains the cornerstone of treatment for ESDN, it does not adequately correct the underlying immune dysregulation or persistent low-grade inflammation, both of which are influenced by the primary disease, dialysis-related factors, and patients' metabolic and nutritional status.[6] Additionally, DN patients frequently exhibit a hypercoagulable state that accelerates disease progression and increases the risk of cardiovascular and cerebrovascular events.[7] These challenges highlight the need for adjunctive pharmacological interventions that provide renal protection, restore the oxidant–antioxidant balance, and mitigate systemic inflammation.[8]

Levocarnitine and alprostadil are two agents with promising roles in this context. Levocarnitine, an essential cofactor for mitochondrial fatty acid transport and β-oxidation, is often depleted in long-term dialysis patients, leading to impaired energy metabolism and worsened nutritional status.[9] Supplementation has been shown to exert antioxidant, anti-inflammatory, and metabolic regulatory effects.[10] Alprostadil, a prostaglandin E1 analog, improves microcirculation and renal hemodynamics, reduces platelet aggregation, and alleviates the hypercoagulable state.[11] Both agents have demonstrated renoprotective effects in DN; however, evidence regarding their combined use—particularly in the ESDN population—is limited.[12]

Emerging findings suggest that levocarnitine and alprostadil may exert complementary benefits by simultaneously targeting oxidative stress, inflammation, and hemodynamic disturbances.[13] Nevertheless, most existing studies involve general DN populations or small sample sizes, leaving a significant evidence gap regarding combination therapy in advanced disease stages such as ESDN.[4]

Therefore, this study evaluates the clinical efficacy of levocarnitine–alprostadil combination therapy in patients with ESDN, focusing on renal protection, improvement of oxidant–antioxidant balance, and reduction of systemic inflammation. The results may offer new therapeutic insights for optimizing management strategies in this high-risk population.

Objectives and Methods

Study Design and Patient Selection

This retrospective cohort study analyzed the medical records of End-Stage Diabetic Nephropathy (ESDN) patients who were treated at our hospital between April 2021 and April 2023. The initial screening identified 120 patients who had received the relevant drug interventions. After applying the inclusion and exclusion criteria, a total of 104 patients were included in the final analysis.

The primary reason for hospitalization was the management of complications associated with ESDN and the receipt of scheduled hemodialysis. Based on the treatment regimens documented in their medical charts, patients were retrospectively categorized into two groups: a control group (n=51) which received Alprostadil plus standard care, and an observation group (n=53) which received a combination of Levocarnitine and Alprostadil on top of standard care. All patients in both groups were on established, regular hemodialysis for chronic kidney disease due to ESDN. This study was conducted following the principles of the "Helsinki Declaration"[14] and received approval from Ethics Committee of Wuhan No.1 Hospital. In accordance with our institution's standard procedure for all hospitalized patients, general informed consent for treatment and the potential use of anonymized data for medical research was obtained from all patients or their legal guardians upon admission. This study utilized anonymized data derived from that process.

Inclusion and Exclusion Criteria

Inclusion Criteria: ① Patients aged 18 years and above. ② No documented use of immunomodulators within the 3 months preceding the study period. ③ Had been undergoing maintenance hemodialysis three times per week for more than 6 months. ④ Clinically estimated survival of more than 6 months. ⑤ Diagnosis of type 2 diabetes mellitus. ⑥ Patients with conscious state, good compliance, and stable vital signs during the recorded period.

Exclusion Criteria: ① Patients with severe non-diabetic comorbidities, including significant heart failure (NYHA Class III–IV), severe liver cirrhosis (Child-Pugh Class B or C), or any non-diabetic primary renal disease. ② Documented history of

severe hypersensitivity to Levocarnitine or Alprostadil. ③ Diagnosis of type 1 diabetes mellitus. ④ Presence of active severe systemic infections, metastatic malignant tumors, or other major organic diseases. ⑤ Documented history of mental disorders or cognitive impairments that could affect treatment adherence or data reliability. ⑥ Patients with incomplete medical records or who were lost to follow-up during the 30-day treatment period.

Methods

As per standard practice for ESDN management at our institution, all patients received health education, instructions on blood sugar control, advice on moderate physical activity, and routine pharmacological therapy. This routine care included glycemic control (primarily with insulin), blood pressure management, correction of electrolyte imbalances, vitamin supplementation, and the use of phosphate binders.

Control Group

Patients in the control group received Alprostadil (Beijing Tide Pharmaceutical Co., Ltd., National Medical Products Administration (NMPA) approval number H10980023) in addition to the standard care. The treatment protocol, as consistently recorded, involved the intravenous infusion of 20 μg Alprostadil dissolved in 100 mL of 0.9% saline, administered once daily after hemodialysis on non-dialysis days or post-dialysis on dialysis days. The treatment course was consistently 30 consecutive days for all included patients.

Observation Group

Patients in the observation group received combination therapy with Levocarnitine (Echo Pharmaceuticals Fuzhou Co., Ltd., NMPA approval number H20113065) in addition to the identical Alprostadil and standard care regimen received by the control group. The recorded protocol for Levocarnitine was the intravenous infusion of 1.0 g dissolved in 100 mL of 0.9% saline, administered once daily. The treatment duration was also 30 consecutive days, ensuring comparability.

Observation Parameters

Clinical Treatment Efficacy

Clinical efficacy was evaluated after the 30-day treatment period based on a retrospective review of medical records, integrating documented changes in core clinical symptoms and objectively measured laboratory parameters. Patients were classified into three predefined categories: "Markedly effective", "Effective", and "Ineffective". The comprehensive criteria are detailed in Table 1.

Clinical Symptom Assessment: Symptom improvement was adjudicated by two independent physicians through a structured review of physician and nursing notes. "Complete resolution" was recorded if the documentation explicitly stated the symptom was "resolved" or "absent" at the end of treatment. "Notable improvement" was defined as a clear descriptive reduction in severity (eg, from "severe" to "mild") in the clinical records. Any discrepancies between reviewers were resolved by consensus with a third senior clinician.

Laboratory Parameter Thresholds: The thresholds for renal function improvement (≥30% or ≥50% reduction from baseline) are commonly used to define clinically relevant response in nephropathy trials. The proteinuria categories (<0.15 g/24h, 0.15–0.5 g/24h, ≥0.5 g/24h) align with the KDIGO 2021 Clinical Practice Guideline for Glomerular Diseases. Although serum levels of inflammatory markers (CRP, IL-1β, IL-6) were measured and reported as exploratory

Table 1 Criteria for Clinical Efficacy Classification

Efficacy Category	Required Clinical Symptom Profile (Edema, Fatigue, Poor Appetite)	Required Renal Function Improvement (From Baseline)
Markedly Effective	Complete resolution of all three core symptoms.	Both serum BUN and cystatin C (Cys-C) decreased by ≥50%. And 24-hour urinary protein (24h Upro) reduced to <0.15 g/24h.
Effective	Notable improvement in at least two of the three core symptoms.	Either serum BUN or Cys-C decreased by ≥30%. And 24h Upro reduced to <0.5 g/24h.
Ineffective	Did not meet the symptom criteria for "Effective", or any symptom worsened.	Did not meet the renal function criteria for "Effective", or any renal parameter worsened from baseline.

mechanistic outcomes, the primary efficacy classification was based solely on the combination of symptom improvement and renal function parameters, as detailed below.

The cumulative treatment effectiveness was calculated as: (number of markedly effective cases + number of effective cases) / total number of cases × 100%.

Renal Function Parameters

Fasting venous blood samples (5 mL) collected routinely before the initiation and after the completion of the 30-day treatment period were analyzed. Serum urea nitrogen (BUN) was measured using the enzymatic rate method. Serum cystatin-C (Cys-C) levels were quantified using enzyme-linked immunosorbent assay (ELISA). Quantification of 24-hour urinary protein (24 h Upro) was performed using radioimmunoassay.

Oxidative Stress Parameters

The stored serum samples obtained for renal function testing were also used to assess oxidative stress. Malondialdehyde (MDA) levels and superoxide dismutase (SOD) activity were measured using colorimetric methods. Reactive oxygen species (ROS) levels were determined using a specific ELISA kit.

Inflammatory Factor Parameters

Serum levels of C-reactive protein (CRP), interleukin-1β (IL-1β), and interleukin-6 (IL-6) were measured from the pre- and post-treatment serum samples using commercially available, high-sensitivity ELISA kits according to the manufacturers' instructions.

Incidence of Adverse Reactions

The incidence of adverse reactions during the treatment period was extracted from nursing records and physician progress notes. Documented adverse events included dizziness, headache, gastrointestinal disturbances (nausea, vomiting, abdominal pain, diarrhea), blood pressure fluctuations, injection site reactions, skin rashes, and respiratory discomfort.

Statistical Analysis

GraphPad Prism 8 was used for data visualization, and SPSS 22.0 was employed for data analysis. For continuous data, the mean and standard deviation were used to describe the distribution, and statistical analysis was performed using *t*-tests or analysis of variance. Categorical data were described using frequency and percentage, and statistical analysis was conducted using the chi-square test or Fisher's exact test. Differences were considered statistically significant when $P<0.05$.

Results

General Data Comparison

The general data of the two groups of patients were comparable, and there were no significant differences in the comparisons ($P>0.05$). Please refer to Table 2 for details.

Comparison of Clinical Treatment Efficacy

The cumulative treatment effectiveness was 78.43% in the control group and 92.45% in the observation group, which was significantly higher in the observation group ($P<0.05$). Please refer to Table 3 for details.

Comparison of Renal Function Parameters

The changes in renal function parameters before and after treatment are shown in Table 4 and Figure 1. Before treatment, no significant differences were found between the two groups in BUN, Cys-C, or 24 h Upro ($P > 0.05$). After 30 days of treatment, all three parameters improved significantly in both groups compared with their baseline levels. The post-treatment levels of BUN, Cys-C, and 24 h Upro were significantly lower in the observation group than in the control group ($P < 0.05$), indicating greater improvement in renal function.

Table 2 General Data Comparison

	Control (n=51)	Observation (n=53)	t/x^2	P
Gender			0.140	0.707
Male	27	30		
Female	24	23		
Age (years)	59.76±5.83	60.11±5.47	0.315	0.752
Disease Duration (years)	5.36±1.15	5.47±1.12	0.494	0.622
BMI (kg/m^2)	22.13±1.37	21.94±1.25	0.739	0.461
Underlying Diseases				
Hypertension	14	16	0.094	0.758
Coronary Heart Disease	17	20	0.219	0.639

Table 3 Comparison of Clinical Treatment Efficacy

Group	n	Markedly Effective	Effective	Ineffective	Cumulative Treatment Effectiveness Rate (%)
Control	51	13	27	11	78.43%
Observation	53	20	29	4	92.45%
x^2	–	–	–	–	4.139
P	–	–	–	–	0.041

Table 4 Comparison of Renal Function Parameters Before and After Treatment (Mean ± SD)

Parameter	Group	Pre-Treatment	Post-Treatment	P (within-group)
BUN (mmol/L)	Control	6.98 ± 1.37	5.29 ± 1.12	< 0.001
	Observation	6.91 ± 1.43	4.35 ± 1.06*	< 0.001
Cys-C (mg/L)	Control	2.33 ± 0.52	1.75 ± 0.46	< 0.001
	Observation	2.29 ± 0.53	1.21 ± 0.34*	< 0.001
24 h Upro (mg/24h)	Control	135.72 ± 28.06	75.17 ± 19.54	< 0.001
	Observation	136.12 ± 27.68	66.79 ± 18.37*	< 0.001

Note: *Indicates a statistically significant difference in the post-treatment value compared to the control group (P < 0.05).

Comparison of Oxidative Stress Parameters

The effects of treatment on oxidative stress indicators are presented in Table 5 and Figure 2. Baseline levels of MDA, SOD, and ROS were comparable between the two groups (P > 0.05). After treatment, the observation group showed significantly lower MDA and ROS levels and significantly higher SOD levels compared with the control group (P < 0.05), reflecting a more favorable oxidative stress profile.

Comparison of Inflammatory Marker Levels

Serum inflammatory marker levels (CRP, IL-1β, and IL-6) are summarized in Table 6 and Figure 3. No significant differences were observed between the groups prior to treatment. After treatment, all three inflammatory markers decreased significantly in both groups. The post-treatment levels of CRP, IL-1β, and IL-6 were significantly lower in the observation group than in the control group (P < 0.05).

Comparison of Adverse Reactions

The adverse reaction incidence in the control group was 13.73%, while in the observation group, it was 16.98%. The comparison of adverse reaction incidence between the two groups showed no significant difference (P>0.05). Please refer to Table 7 for details.

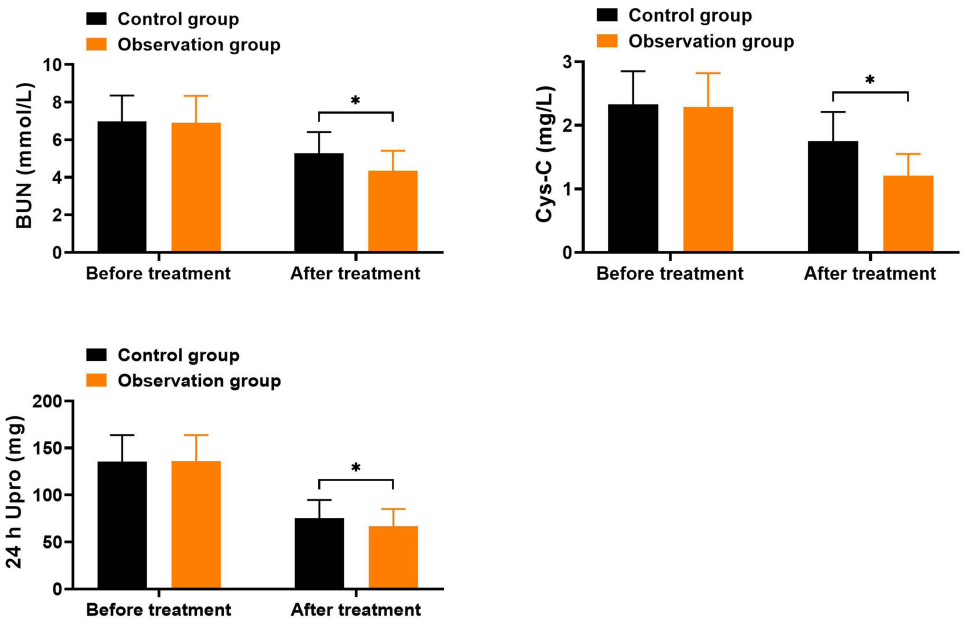

Figure 1 Comparison of Renal Function Parameters.
Note: *Indicates a statistically significant intergroup difference (P<0.05).

Discussion

This retrospective study evaluated the clinical efficacy of combined Levocarnitine and Alprostadil therapy in patients with end-stage diabetic nephropathy (ESDN). The principal findings indicate that the combination therapy was associated with a significantly higher cumulative treatment effectiveness, greater improvements in renal function parameters, a more favorable shift in the oxidant-antioxidant balance, and a more substantial reduction in systemic inflammation compared to Alprostadil alone, without a significant increase in adverse events.

The progression of diabetes to ESDN involves a complex interplay of metabolic and hemodynamic factors. Chronic hyperglycemia induces the formation of advanced glycation end products, activates protein kinase C, and enhances polyol and hexosamine pathways, leading to glomerular hypertension, podocyte injury, tubulointerstitial fibrosis, and eventual renal failure.[15,16] Within this pathogenic framework, oxidative stress and chronic inflammation are recognized as central mediators of renal damage.[17] Our results demonstrate that the addition of Levocarnitine to Alprostadil-based treatment was associated with a superior clinical response. The cumulative treatment effectiveness was 92.45% in the combination group versus 78.43% in the Alprostadil-only group. This suggests a potential additive or synergistic interaction between the two drugs.

The observed renoprotective effects, evidenced by significantly greater reductions in BUN, Cys-C, and 24 h Upro in the observation group, can be attributed to the distinct yet complementary mechanisms of each drug. Alprostadil,

Table 5 Comparison of Oxidative Stress Parameters Before and After Treatment (Mean ± SD)

Parameter	Group	Pre-Treatment	Post-Treatment	P (within-group)
MDA (nmol/mL)	Control	5.94 ± 1.15	4.63 ± 1.08	< 0.001
	Observation	5.97 ± 1.09	3.54 ± 0.89*	< 0.001
SOD (U/mL)	Control	61.04 ± 8.05	72.49 ± 8.71	< 0.001
	Observation	60.45 ± 8.24	88.17 ± 9.34*	< 0.001
ROS (U/mL)	Control	489.76 ± 53.12	417.53 ± 48.16	< 0.001
	Observation	492.47 ± 51.03	371.34 ± 46.32*	< 0.001

Note: *Indicates a statistically significant difference in the post-treatment value compared to the control group (P < 0.05).

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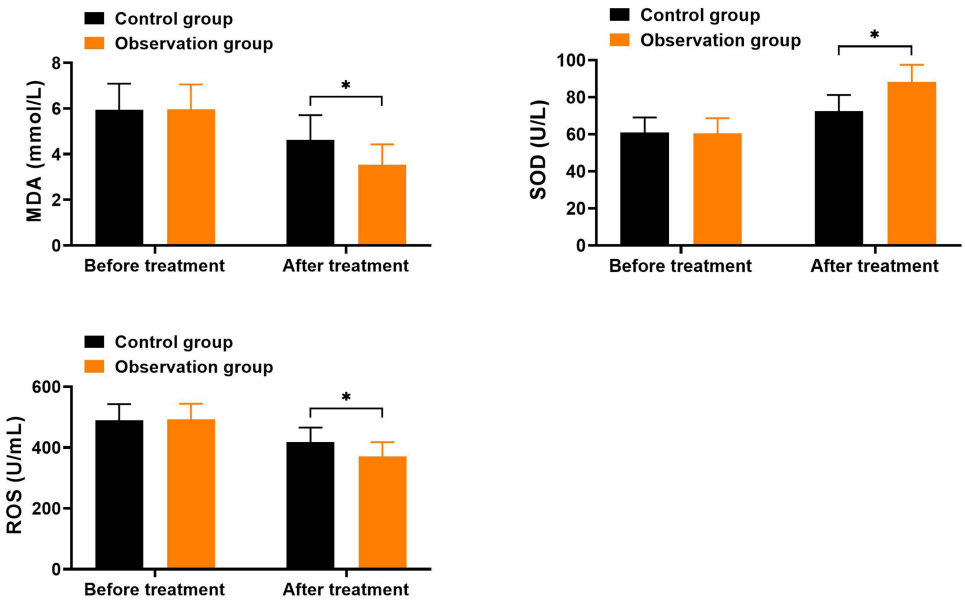

Figure 2 Comparison of Oxidative Stress Parameters.
Note: *Indicates a statistically significant intergroup difference (P<0.05).

a synthetic prostaglandin E1 analog, exerts its effects primarily through vasodilation of renal arteries, improvement of intra-renal microcirculation, and inhibition of platelet aggregation.[18] This aligns with findings from Xi et al, who reported that Alprostadil-based regimens significantly reduce proteinuria and preserve glomerular filtration rate in DN patients.[19] Levocarnitine plays a critical role in cellular energy metabolism by facilitating the transport of long-chain fatty acids into mitochondrial matrices for β-oxidation.[20] In the context of ESDN, a state of carnitine deficiency often exists due to losses during dialysis, impairing energy production and promoting the accumulation of toxic fatty acid intermediates in renal cells.[21] Levocarnitine supplementation can correct this deficit, potentially restoring energy homeostasis in surviving renal cells and mitigating cellular injury.

The synergistic mechanism for enhanced efficacy likely resides in this multi-targeted approach. Alprostadil primarily addresses the hemodynamic and anti-thrombotic aspects of renal injury, improving blood flow and oxygen delivery. Concurrently, Levocarnitine addresses the underlying metabolic dysfunction in energy-starved renal cells. By improving the cellular energy state, Levocarnitine may enhance the viability of renal tissues whose perfusion is being improved by Alprostadil. This combination of improved delivery of oxygen and nutrients (via Alprostadil) and enhanced capacity for their utilization (via Levocarnitine) may underpin the superior recovery of renal function observed.

Our data further show that the combination therapy was associated with a more pronounced correction of oxidative stress. The observation group exhibited a significantly greater decrease in MDA and ROS alongside a higher increase in

Table 6 Comparison of Inflammatory Marker Levels Before and After Treatment (Mean ± SD)

Parameter	Group	Pre-Treatment	Post-Treatment	P (within-group)
CRP (mg/L)	Control	8.63 ± 1.07	6.63 ± 0.94	< 0.001
	Observation	8.46 ± 1.11	5.02 ± 0.83*	< 0.001
IL-1β (pg/mL)	Control	16.51 ± 3.73	13.61 ± 2.67	< 0.001
	Observation	16.36 ± 3.64	11.04 ± 2.38*	< 0.001
IL-6 (pg/mL)	Control	23.01 ± 5.73	16.84 ± 4.53	< 0.001
	Observation	22.48 ± 5.86	12.78 ± 3.51*	< 0.001

Note: *Indicates a statistically significant difference in the post-treatment value compared to the control group (P < 0.05).

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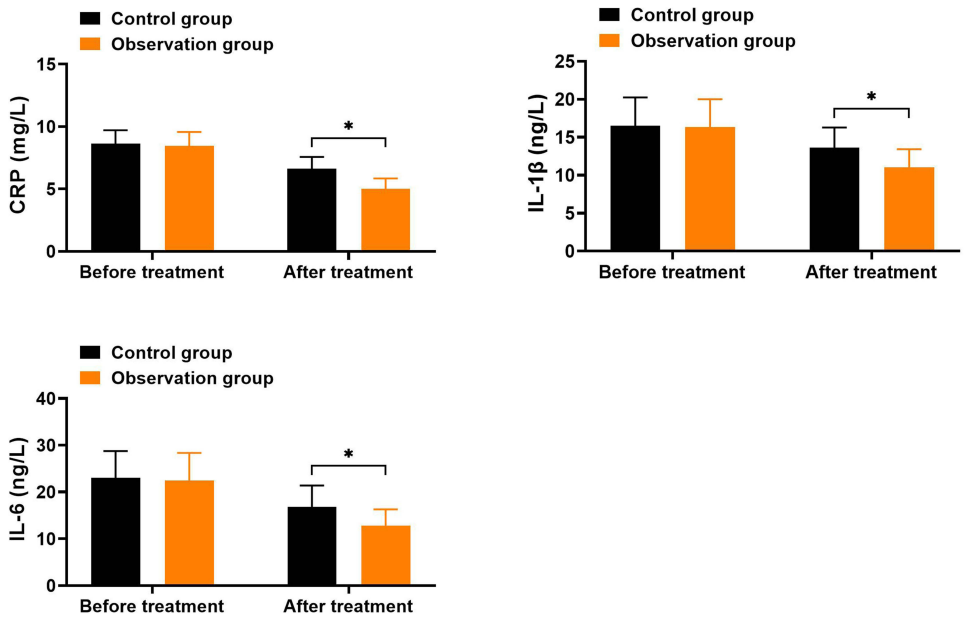

Figure 3 Comparison of Inflammatory Marker Levels.
Note: *Indicates a statistically significant intergroup difference (P<0.05).

SOD activity compared to the control group. Oxidative stress, characterized by an overproduction of ROS like O2- and H2O2, is a well-established driver of diabetic renal injury, damaging lipids, proteins, and DNA.[22,23] Alprostadil has documented antioxidant properties, potentially through the suppression of NADPH oxidase activity.[24] Levocarnitine contributes directly to the antioxidant defense by scavenging various free radical species and stabilizing mitochondrial membranes, thereby reducing ROS generation.[25] The enhanced anti-inflammatory mechanism observed may be a direct consequence of this superior antioxidant effect. Oxidative stress and inflammation are closely intertwined; ROS can activate key pro-inflammatory signaling pathways such as NF-κB, leading to the transcription and release of cytokines including IL-1β and IL-6.[26] By more effectively quenching oxidative stress, the Levocarnitine-Alprostadil combination may have resulted in a greater downregulation of this inflammatory cascade. This is consistent with our findings of significantly lower post-treatment levels of CRP, IL-1β, and IL-6 in the observation group. The anti-inflammatory properties of both drugs, thus, appear to work in concert, with Alprostadil modulating inflammatory responses and Levocarnitine reducing one of its fundamental triggers.

Regarding safety, the incidence of adverse reactions was 16.98% in the observation group and 13.73% in the control group, with no statistically significant difference between them. This indicates that the combination of Levocarnitine and Alprostadil does not appreciably increase the risk of common adverse drug reactions in ESDN patients over a 30-day treatment period and exhibits a acceptable safety profile.

Table 7 Comparison of Adverse Reactions

Adverse Reactions	Control (n=51)	Observation (n=53)	x^2	P
Dizziness and Headache	1	3	–	–
Nausea and Vomiting	2	1	–	–
Abdominal Pain and Diarrhea	2	1	–	–
Blood Pressure Reactions	1	2	–	–
Skin Reactions	0	1	–	–
Respiratory Reactions	1	1	–	–
Total Incidence (%)	13.73%	16.98%	0.211	0.645

While our findings demonstrate that Levocarnitine–Alprostadil combination therapy improves surrogate markers of renal injury, oxidative stress, and inflammation in ESDN patients already on maintenance hemodialysis, it is important to acknowledge that these patients represent an advanced disease stage where structural renal damage is largely irreversible. Consequently, the observed improvements in biomarkers such as BUN, Cys-C, and proteinuria likely reflect mitigation of ongoing tubulointerstitial injury and systemic metabolic derangements rather than true recovery of glomerular filtration sufficient to discontinue dialysis. Indeed, none of the patients in either group were able to cease hemodialysis during or after the 30-day intervention, consistent with the expected natural history of ESDN.

Several limitations of this study must also be acknowledged, primarily stemming from its retrospective design, which introduces risks of selection bias and unmeasured confounding. The modest sample size, short (30-day) intervention period, and lack of long-term follow-up further constrain the generalizability of our findings and preclude assessment of hard clinical endpoints such as impact on dialysis-free survival, cardiovascular events, or mortality.

These limitations, coupled with the inherent constraints of studying an end-stage population, clearly delineate the path for future research. Given that the primary clinical goal in diabetic kidney disease is to prevent or delay progression to ESRD, the promising biologic activity observed here must be evaluated in earlier stages of CKD (eg, stages 2–3). Prospective, randomized controlled trials with larger sample sizes and longer follow-up are warranted to determine if Levocarnitine-Alprostadil combination therapy can modify the long-term renal trajectory. Furthermore, given the high cardiovascular burden in diabetes, such trials should incorporate assessments of systemic benefits, including cardiac and vascular endpoints (eg, arterial stiffness, endothelial function, major adverse cardiovascular events), to fully characterize the therapeutic potential of this dual-pathway approach.

Conclusion

In this cohort of ESDN patients, the combination of Levocarnitine and Alprostadil was associated with a significantly higher cumulative treatment effectiveness (92.45%) compared to Alprostadil alone (78.43%). The combination therapy demonstrated superior outcomes in improving renal function, ameliorating oxidative stress, and attenuating systemic inflammation. The safety profile of the combination was acceptable, with no significant increase in the incidence of monitored adverse reactions. However, the retrospective nature of this analysis and the specific set of adverse events recorded cannot completely rule out other potential adverse effects not captured in this study. The findings suggest that Levocarnitine-Alprostadil combination therapy may be a beneficial adjunctive treatment strategy for ESDN, warranting further investigation in rigorous clinical trials, including studies in non-dialysis dependent diabetic kidney disease populations.

Disclosure

The authors report no conflicts of interest in this work.

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