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*Original Article*

# Efficacy of continuous ambulatory peritoneal dialysis combined with hemodialysis versus single hemodialysis in patients with end-stage renal disease

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**Abstract:** Objective: This study aimed to compare the efficacy of single hemodialysis (HD) and continuous ambulatory peritoneal dialysis (CAPD) combined with HD in the treatment of end-stage renal disease. Methods: Seventy patients with end-stage renal disease in our hospital from January 2019 to December 2020 were included and divided into 35 patients in the single group (SG) and 35 patients in the combination group (CG) according to a random number table. The SG received HD treatment and the CG received CAPD combined with HD treatment. Results: Hemoglobin and serum albumin levels were higher, blood urea nitrogen (BUN) and serum creatinine (Scr) levels were lower, and interleukin-6 (IL-6), C-reactive protein (CRP), and tumor necrosis factor-α (TNF-α) levels were lower in the CG than in SG at the end of treatment ($P < 0.05$). $Ca^{2+}$ levels were higher and $P^{3+}$ levels were decreased at the end of treatment in both groups compared with those before treatment ($P < 0.05$), and $Ca^{2+}$ and $P^{3+}$ levels at the end of treatment in the CG were not different from those in the SG ($P > 0.05$). The complication rate in the CG was 5.71%, which was lower than 25.71% in the SG ($P < 0.05$). Quality of life scores were higher in the CG than in the SG at the end of treatment ($P < 0.05$). Conclusion: CAPD combined with HD can improve renal function and nutritional levels more significantly, control inflammatory responses more effectively, and reduce complications compared to single HD treatment in patients with end-stage renal disease.

**Keywords:** Renal disease, end-stage, CAPD, hemodialysis, treatment, efficacy

## Introduction

End-stage renal disease is the terminal stage of chronic kidney disease and also known as uremia, in which patients exhibit a continuous, irreversible decrease in renal function until complete loss of kidney function occurs [1]. Patients with end-stage renal disease must receive renal replacement therapy (RRT) to prolong survival, but the medical costs and poor prognosis are heavy burdens on the patient's family [2].

Renal transplantation, hemodialysis (HD), and peritoneal dialysis (PD) are common renal replacement therapies. Although renal transplantation is effective, kidney sources are scarce and hard to match, so HD has become the primary treatment [3]. HD and PD have been proven to have respective advantages and shortcomings in clinical application and with the continuous progress of research, some scholars believed that a combination of HD and PD could achieve complementary advantages and enhance the efficacy of dialysis as well as the nutritional status of patients, leading to a lower incidence of complications [4, 5]. However, most of the studies were retrospective analyses or had a short follow-up period, and did not comprehensively elaborate the value of HD + PD treatment in end-stage renal disease, especially the lack of study on the combination treatment of continuous ambulatory peritoneal dialysis (CAPD) + HD.

In this study, 70 patients with end-stage renal disease from January 2019 to December 2020 were prospectively enrolled to compare the efficacy of single HD treatment with CAPD and HD combination treatment.

## Materials and methods

### *Clinical data*

Seventy patients with end-stage renal disease in our hospital from January 2019 to December 2020 were divided into 35 patients in the single group (SG) and 35 patients in the combination group (CG) according to a random number table method. Inclusion criteria: patients met the diagnostic criteria for chronic kidney disease [6], clinical stage V [7], complete clinical data, expected survival time of > 6 months, and duration of CAPD ranged 24 and 36 months. Patients voluntarily signed the consent form, and the study was approved by the Ethics Committee of the First Affiliated Hospital of Gannan Medical University. Exclusion criteria: patients who were comorbid with pericardial effusion, hypoproteinemia, peritoneal infection, malignancy, severe malnutrition, active peptic ulcer, cardiovascular disease, low compliance and inability to complete treatment were excluded prior to study participation.

### *Methods*

SG: AK95S hemodialysis machine (Kimball, Sweden) was applied, including hollow fiber dialyzer, anticoagulation with heparin, a synthetic membrane as the dialysis membrane and bicarbonate buffer as the dialysis solution. The blood flow rate was controlled to 200 mL/min, with a dialysis solution flow rate of 500 mL/min. Each cycle of dialysis treatment lasted 4 hours, and treatment was performed 1-2 times a week.

CG: The peritoneal dialysis tube was inserted through surgical incision. Under epidural anesthesia, the surgical incision was made 2 cm below the umbilicus and 1 cm to the right of the midline of the abdomen. The abdomen was routinely opened and separated layer by layer until the peritoneum was located. The peritoneum was cut open, the anterior segment of the peritoneal dialysis tube was placed into rectovesical pouch under the guidance of guidewire, and the side of the catheter head was placed outside the peritoneum. A small amount of peritoneal dialysis fluid was injected into the peritoneal dialysis tube and peritoneal sutures were performed after the peritoneum could be drained smoothly. The anterior Kuff end was reinforced and the anterior Kuff head was embedded between the peritoneum and the anterior rectus abdominis sheath, and the posterior Kuff end was left subcutaneously, 2-3 cm away from the location of skin penetration, with the lateral side as the exit of the catheter. After the placement of the tube, peritoneal dialysis was performed through a dual system with 1.5%-2.5% concentration of bagged dialysate. The daily dialysis volume was controlled at 6-8 L. Two to three exchanges were performed during the day, each with a stay in the abdominal cavity for about 5 hours, followed by draining the dialysate out of the body, and so on, with one exchange at night and it stayed in the abdomen for about 11 hours. With one week used as a treatment cycle, CAPD treatment was performed on the first five days and HD treatment performed in combination on day 6 in the same way as in the SG, and HD treatment was stopped with CAPD treatment on day 7 of the treatment cycle. Both treatments continued for 6 months in the two groups.

### *Outcome measurement*

Nutritional status: hemoglobin and serum albumin levels were measured in both groups before and after treatment, respectively, and 3 mL of fasting venous blood was drawn from both groups, and the two indices were tested by a fully automatic biochemical analyzer.

Renal function: Blood urea nitrogen (BUN) and serum creatinine (Scr) levels were measured in both groups before and after treatment, respectively, by drawing 5 mL of fasting venous blood, followed by measurement using a fully automated biochemical assay.

Ionic levels: serum calcium ($Ca^{2+}$) and blood phosphorus ($P^{3+}$) levels were measured in both groups before and after treatment, respectively, and fasting venous blood was drawn in the early morning, and serum was extracted after centrifugation and was tested using a fully automated biochemical analyzer with *in vitro* diagnostic kits (Lidman).

Inflammatory factors: C-reactive protein (CRP), tumor necrosis factor-α (TNF-α), and interleukin-6 (IL-6) levels were measured before and after treatment in both groups, respectively. A total of 10 mL of fasting venous blood was collected from both groups in the early morning, centrifuged and processed, and the serum was

**Table 1.** Comparison of baseline data ($\bar{x}$±s)/[n (%)]

| Data | | Combination group (n=35) | Single group (n=35) | $t/\chi^2$ | *P* |
|---|---|---|---|---|---|
| Gender | Male | 20 (57.14) | 22 (62.86) | 0.238 | 0.626 |
| | Female | 15 (42.86) | 13 (37.14) | | |
| Age (years) | | 56.86±12.17 | 58.71±13.31 | 0.607 | 0.546 |
| Duration of illness (years) | | 5.16±2.19 | 5.31±2.32 | 0.278 | 0.782 |
| GFR (mL/min) | | 11.12±2.16 | 11.18±2.31 | 0.112 | 0.911 |
| Causes | Chronic glomerulonephritis | 16 (45.71) | 15 (42.86) | 0.183 | 0.316 |
| | Diabetic nephropathy | 7 (20.00) | 8 (22.86) | | |
| | Hypertensive nephropathy | 8 (22.86) | 9 (25.71) | | |
| | Others | 4 (11.43) | 3 (8.57) | | |

stored at -75°C. The CRP was measured by a 7600 automatic biochemical analyzer, and the serum IL-6 (Abcam, No. ab100572) and TNF-α (Shanghai Jianglai Biotechnology Co., Ltd., No. Rayto RT-610) were measured by a Siemens automatic protein analyzer by enzyme-linked immunoassay (ELISA).

Complications: The incidence of abdominal infection, hypoproteinemia, pericardial effusion, congestive heart failure, and arrhythmias were compared between the two groups.

Quality of life was evaluated using The World Health Organization Quality of Life Instrument-Short Form (WHOQOL-BREF) [8], containing 6 questions in the physical area (PH), 6 questions in the psychological area (PS), 7 questions in the environmental field (EN), and 7 questions in Social Relations (SR) on a 1-5 Likert scale, scoring 6-30, 6-30, 7-35, and 7-35 accordingly, with the higher score indicating the higher quality of life.

*Statistical methods*

Statistical analysis was performed using SPSS 23.0. Count data were represented by [n (%)] and examined by $\chi^2$ test. Measurement data were represented by ($\bar{x}$±s) and examined by *t* test. Graphs were made by Graphpad Prism 8. $P < 0.05$ was considered statistically significant.

## Results

*General information*

There was no significant difference in the ratio of males versus females, mean age, mean duration of disease, mean glomerular filtration rate (GFR), and type of nephropathogenesis between the two groups ($P > 0.05$) (**Table 1**).

*CAPD and HD combination treatment improved nutritional status*

The differences in hemoglobin and serum albumin levels between the CG and the SG before treatment were not statistically significant ($P > 0.05$). Both groups had significantly higher hemoglobin and serum albumin levels at the end of treatment compared to those before treatment ($P < 0.05$), and hemoglobin and serum albumin levels at the end of treatment were higher in the CG than in the SG ($P < 0.05$) (**Figure 1**).

*CAPD and HD combination treatment improved renal function*

The differences in BUN and Scr levels between the two groups before treatment were not statistically significant ($P > 0.05$). BUN and Scr levels were decreased significantly after treatment in both groups ($P < 0.05$), and they were lower in the CG than in the SG at the end of treatment ($P < 0.05$) (**Figure 2**).

*CAPD and HD combination treatment improved calcium and phosphorus metabolism*

The differences in $Ca^{2+}$ and $P^{3+}$ levels between two groups before treatment were not statistically significant ($P > 0.05$). $Ca^{2+}$ levels were significantly higher and $P^{3+}$ levels were significantly lower ($P < 0.05$) in both groups at the end of treatment. $Ca^{2+}$ and $P^{3+}$ levels did not differ significantly between the two groups ($P > 0.05$) (**Figure 3**).

*CAPD and HD combination treatment controlled the inflammatory response*

The differences in CRP, TNF-α, and IL-6 levels between the two groups before treatment were not statistically significant ($P > 0.05$). CRP, TNF-

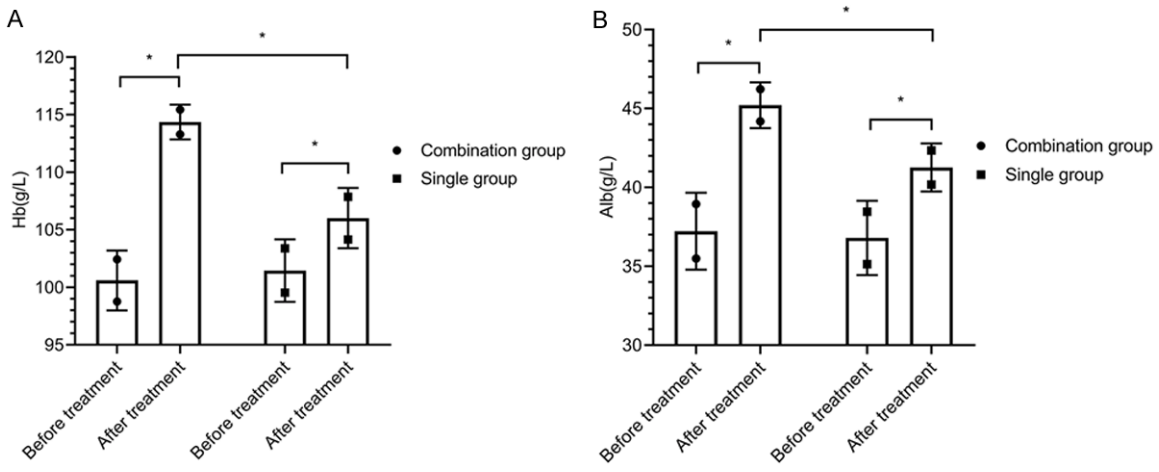


**Figure 1.** Comparison of nutritional status between the two groups. Hemoglobin (A) and serum albumin (B) levels. *indicates $P < 0.05$.

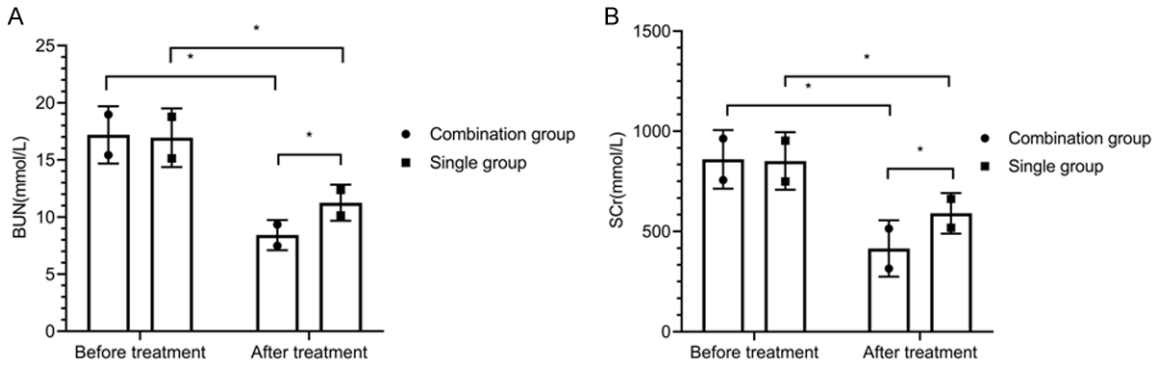


**Figure 2.** Comparison of renal function between the two groups. BUN (A) and Scr (B) levels. *indicates $P < 0.05$.

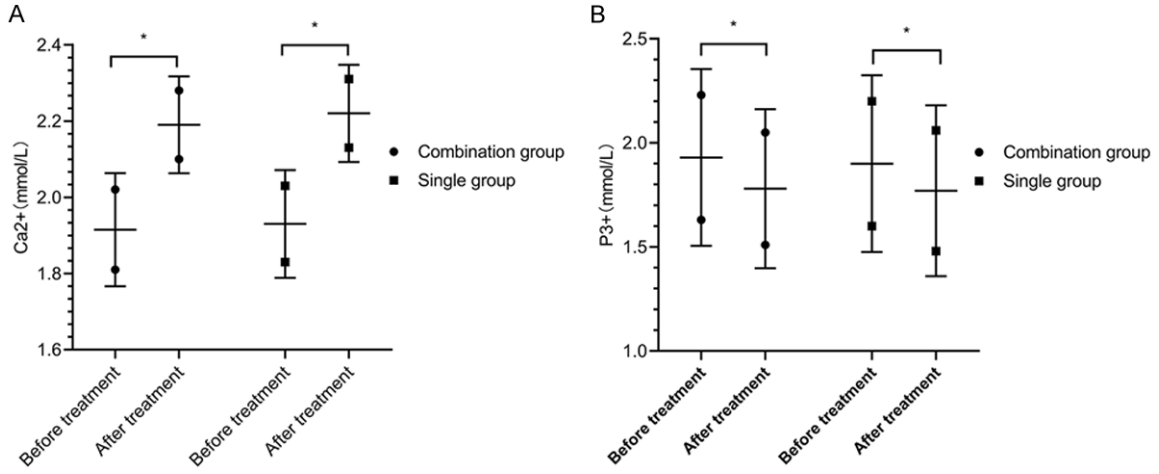


**Figure 3.** Comparison of ion levels between the two groups. $Ca^{2+}$ (A) and $P^{3+}$ (B) levels. *indicates $P < 0.05$.

α, and IL-6 levels in both groups were lower after treatment ($P < 0.05$), and they were lower in the CG than in the SG after treatment ($P < 0.05$) (**Figure 4**).

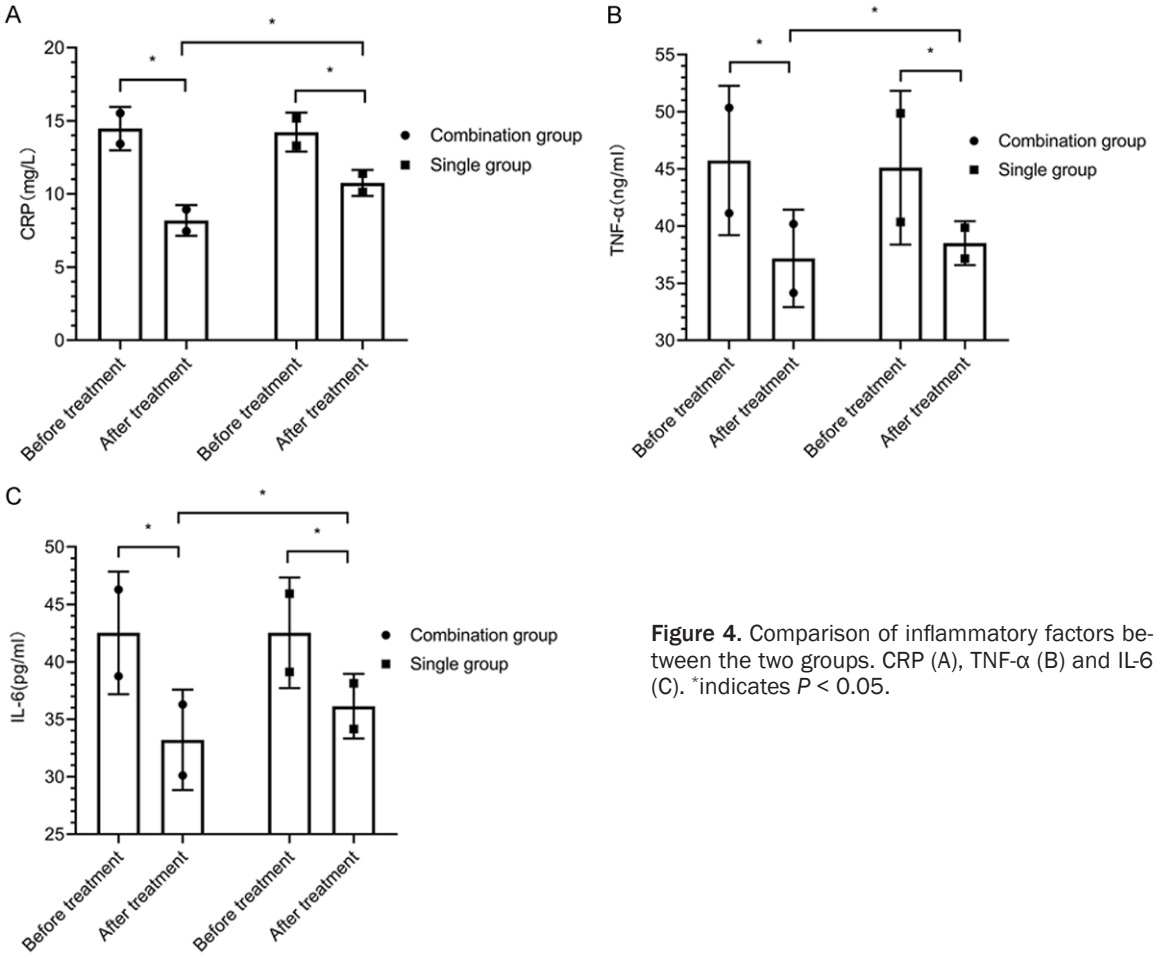


**Figure 4.** Comparison of inflammatory factors between the two groups. CRP (A), TNF-α (B) and IL-6 (C). *indicates $P < 0.05$.

*CAPD and HD combination treatment reduced the complication rate*

The CG showed a complication rate of 5.71%, which was significantly lower than 25.71% in the SG ($P < 0.05$) (**Table 2**).

*CAPD and HD combination treatment enhanced quality of life*

The differences in the scores of items in WHOQOL-BREF before treatment were not statistically significant ($P > 0.05$). The scores of items in WHOQOL-BREF were higher in both groups at the end of treatment than those before treatment ($P < 0.05$), and they were higher in the CG than in the SG ($P < 0.05$) (**Figure 5**).

## Discussion

Patients with end-stage renal disease are approaching loss of renal function, resulting in the inability of the kidneys to excrete excess water and metabolic wastes in a timely manner; a condition that, if left untreated, may further lead to multiple physiological dysfunctions [9]. End-stage renal disease is the terminal stage of renal failure with a high mortality rate [10]. Stimulated by immune complexes and endotoxins, macrophages are activated, leading to the release of a large number of inflammatory factors, inducing a microinflammatory response in patients with end-stage renal disease [11]. When toxins gradually accumulate, they will trigger a variety of gastrointestinal adverse reactions, resulting in metabolic disorders, endocrine dysfunction, decreased synthesis of proteins, and some patients may have resulting malnutrition [12, 13]. It was found that patients comorbid with malnutrition had a significantly higher risk of immunity and infection than patients with normal nutritional status [14].

In this study, hemoglobin and serum albumin levels were higher, BUN and Scr levels were

**Table 2.** Comparison of complication rates [n (%)]

| Group | Abdominal infection | Hypoproteinemia | Pericardial effusion | Congestive heart failure | Cardiac arrhythmias | Total incidence |
|---|---|---|---|---|---|---|
| Combination group (n=35) | 0 (0.00) | 1 (2.86) | 1 (2.86) | 0 (0.00) | 0 (0.00) | 2 (5.71) |
| Single group (n=35) | 2 (5.71) | 3 (8.57) | 1 (2.86) | 1 (2.86) | 2 (5.71) | 9 (25.71) |
| $\chi^2$ | - | - | - | - | - | 3.883 |
| *P* | - | - | - | - | - | 0.049 |

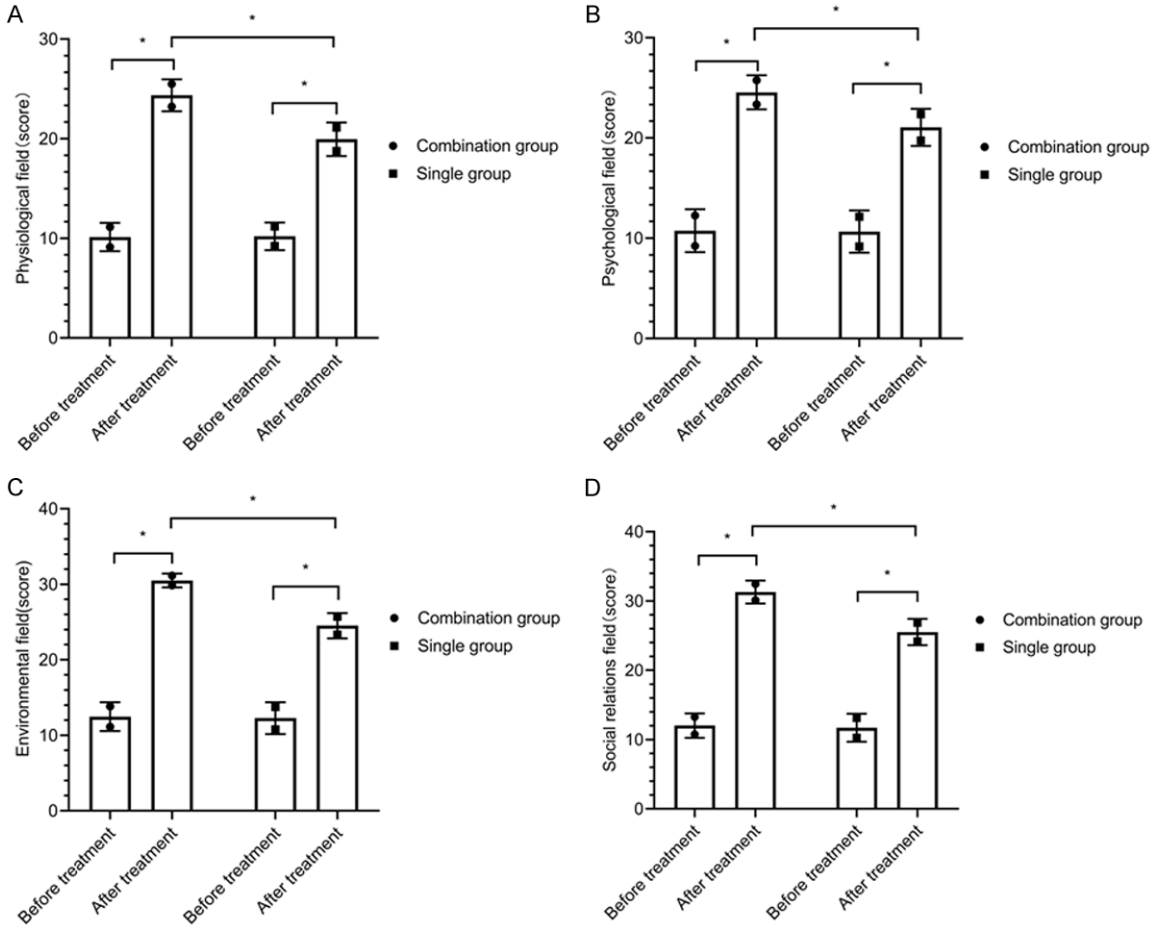


**Figure 5.** Comparison of quality of life between the two groups. Physical domain (A), psychological domain (B), environmental domain (C) and social relationship domain (D). *indicates $P < 0.05$.

lower, and IL-6, CRP, and TNF-α levels were lower in the CG than in the SG at the end of treatment ($P < 0.05$), indicating that CAPD combined with HD treatment can more significantly improve the nutritional status and renal function of patients and more effectively control the inflammatory response. The lack of biocompatibility of dialysis membranes in single HD treatment leads to a higher level of an inflammatory response, while the combination treatment of CAPD and HD enhances the biocompatibility of dialysis membranes and allows for complete removal of excess water and metabolic wastes present in the body, thus providing better control of inflammatory levels and minimizing the adverse effects of the inflammatory response and protecting residual renal function, which contributes to better renal function in the CG [15, 16]. A study also showed that IL-6, CRP, and TNF-α levels were significantly lower in patients with end-stage renal disease treated with CAPD and HD combination treatment than

those with either CAPD or HD treatment ($P < 0.05$) [17], which was consistent with the results of the present study. CAPD and HD combination treatment can further accelerate protein synthesis compared to single HD treatment, allowing the correction of the anemic state, and therefore reducing malnutrition in patients or the pre-existing malnutrition state can be corrected [18].

Disorders of calcium and phosphorus metabolism are frequent complications in patients with end-stage renal disease, and their persistence gradually impairs multisystem functions and increases the risk of adverse cardiovascular events [19, 20]. In this study, $Ca^{2+}$ levels increased and $P^{3+}$ levels were decreased at the end of treatment in both groups, but there was no significant difference between the two groups, indicating that both treatments improved calcium and phosphorus metabolism in patients with end-stage renal disease. The reason may be that HD is effective in the removal of small molecules of toxins, CAPD removes not only small molecules but also medium molecules, while calcium and phosphorus are both small molecules; therefore the combination treatment did not show a superior effect of CAPD over HD [21, 22]. A similar study conducted a therapeutic comparison of HD and CAPD treatments found no significant difference in calcium and phosphorus clearance rate between the two methods [23], which was consistent with the results of this study. The complication rate in this study was 5.71% in the CG, which was lower than 25.71% in the SG ($P < 0.05$), suggesting that CAPD combined with HD treatment could decrease complication rate, which may due to the fact that CAPD treatment maintains hemodynamic stability during the treatment, as it has significantly less impact on the body, and is simpler and safer to perform [24]. Moreover, CAPD adopts a continuous ambulatory model, which has less impact on patients' lives and gives them the opportunity to maintain a normal life between treatments, so patients have a higher quality of life [25]. In this study, quality of life was higher in the CG than in the SG ($P < 0.05$). This may be achieved by better control of inflammatory response, more significant improvement in renal function, improved nutritional level and fewer complications after treatment with CAPD combined with HD, and thus the quality of life was higher.

In summary, CAPD in combination with HD may improve renal function and nutritional levels more significantly, control inflammatory responses more effectively, and reduce complications over single HD treatment in patients with end-stage renal disease. However, this study also has some limitations, which are reflected in the small number of research subjects, and the study only had two groups as it was carried out. All of these affect the results and representativeness of the research, which need to be supplemented and improved in the future research.

## Disclosure of conflict of interest

None.

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