Am J Transl Res 2026;18(2):1136-1144
www.ajtr.org /ISSN:1943-8141/AJTR0169663

Original Article

Specialized nursing improves clinical outcomes in pediatric AKI patients undergoing CRRT: a retrospective cohort study

Hui Zhang, Bixia Li, Huimin Guo, Dan Yi, Qiong He

Pediatric Intensive Care Unit, Hainan Women and Children's Medical Center, Haikou 571000, Hainan, The People's Republic of China

Received October 29, 2025; Accepted December 10, 2025; Epub February 15, 2026; Published February 28, 2026

Abstract: Objective: The purpose of this study was to assess how a multidisciplinary specialized nurse intervention affected the prognosis of pediatric patients undergoing continuous renal replacement therapy (CRRT) for acute kidney injury (AKI). Methods: A total of 140 children having CRRT (January 2022-December 2024) were divided into two groups in this single-center retrospective cohort study: a routine care group (n = 68) or a specialized nursing group (n = 72). Unplanned CRRT interruptions, complications, treatment duration, recovery of renal function, length of stay, and family satisfaction were among the outcomes that were compared. Results: Unplanned CRRT interruptions and overall complications were significantly reduced in the specialized nursing group (25.00% vs. 85.29%, $P < 0.001$). Additionally, this group showed shorter total CRRT duration (46.09 ± 1.46 vs. 52.69 ± 1.40 hours), faster renal recovery (creatinine reduction: 5.26 ± 0.17 vs. 6.87 ± 0.29 hours; urine output normalization: 3.86 ± 0.14 vs. 5.07 ± 0.18 hours), shorter hospital stay (10.98 ± 0.76 vs. 14.11 ± 0.92 days), and higher family satisfaction scores (86.29 ± 3.57 vs. 67.13 ± 4.78), all $P < 0.05$. Conclusion: By lowering complications, speeding recovery, minimizing hospital stays, and improving family satisfaction, the multidisciplinary specialized nursing model dramatically improves clinical outcomes in pediatric AKI patients undergoing CRRT.

Keywords: Acute kidney injury, children, continuous renal replacement therapy, specialized nursing, treatment outcomes

Introduction

A fast loss in renal function is the hallmark of acute kidney injury (AKI), a common and dangerous consequence in the pediatric intensive care unit (PICU). As an important public health concern, AKI is significantly linked to higher mortality, longer hospital stays, and long-term renal impairment in children, with an estimated incidence of 3.5-5.0 per 1,000 hospital admissions [1]. Continuous renal replacement therapy (CRRT) is an essential extracorporeal life-support technique for critically unwell infants with AKI and hemodynamic instability or multi-organ failure. CRRT supports metabolic and fluid balance by facilitating continuous solute clearance and volume management through the simulation of glomerular filtration [2].

CRRT management in pediatric populations is still particularly difficult, despite its well-established significance. Children are more likely to experience issues like circuit clotting, hemodynamic instability, and electrolyte imbalances due to technical and physiological limitations, such as reduced circulatory reserve, decreased vascular access, and a larger surface-area-to-mass ratio [3-5]. These characteristics may be the cause of the persistently high mortality rate among juvenile AKI patients, which is still between 30% and 80% despite advancements in CRRT technology [3, 6]. They also contribute to high rates of treatment cessation (over 35% in some cases). It is becoming more and more clear that improving technology by itself is not enough to maximize results; in order to properly manage these hazards unique to children, high-quality, specialized nursing care is needed.

In this setting, specialized nursing is a multimodal strategy that incorporates metabolic

https://doi.org/10.62347/WGQU7732

support, tailored anticoagulation, precise volume management, and psychosocial care. Although a multidisciplinary team (MDT) is essential to provide such all-encompassing care, there has been little rigorous assessment of structured nursing interventions in pediatric CRRT [7, 8]. Few studies have looked at how nursing models affect clinical outcomes including circuit length, complication rates, and renal recovery; the majority of current research focuses on technical elements of CRRT [9, 10]. Furthermore, the information that is now available is frequently based on single-center experiences or it lacks methodological rigor, which leaves important aspects of the nursing role - like family integration, psychological support, and long-term follow-up - understudied.

This retrospective cohort study intends to close these gaps by assessing how organized, interdisciplinary specialized nursing care affects important clinical outcomes in children with AKI receiving CRRT. We want to provide evidence in favor of incorporating nurse-led, protocol-driven models into standard CRRT practice by comparing results between patients receiving specialized nursing and those receiving routine care.

Materials and methods

Study design

Children with AKI who had CRRT in a tertiary PICU between January 2022 and December 2024 were included in this single-center, retrospective cohort research. Patients were assigned to either a standard care group (n = 68) or a specialized nursing group (n = 72) based on the nursing model. The purpose of the study was to assess how the specialized nursing intervention affected clinical outcomes. Every patient's information was anonymized and kept on a safe, encrypted hospital server. The institutional ethics committee approved the study protocol (Approval No: HNWCMC Review 2025 No. [67]).

Eligibility criteria

Inclusion criteria: (1) Age ≤ 18 years; (2) Diagnosis of AKI during PICU admission, fulfilling the Kidney Disease: Improving Global Outcomes (KDIGO) criteria; (3) Received CRRT treatment for ≥ 24 hours; (4) Availability of complete clinical data, including nursing records, laboratory results, and imaging reports.

Exclusion criteria: Patients were excluded for any of the following: (1) Presence of congenital renal anomalies (e.g., polycystic kidney disease, renal agenesis) or pre-existing chronic kidney disease (CKD stages 3-5); (2) Transfer to another hospital or discharge against medical advice during CRRT, resulting in incomplete data collection; (3) Diagnosis of end-stage malignant tumors or other irreversible, non-renal organ failures.

Sample size calculation

Power Analysis and Sample Size (PASS) 15.0 software was used to determine the sample size. A minimum of 48 patients per group were needed, based on an imagined 40% incidence of unplanned CRRT interruptions in the standard care group and a predicted reduction to 25% (absolute reduction 15%) with the specialist nursing intervention (two-sided α = 0.05; statistical power = 70%). The target sample size was determined at 53 patients per group to account for a 10% attrition rate. Initially, 68 and 74 patients were assigned to the routine care group and the specialized nursing group, respectively, over the study period. The final analysis contained 72 and 68 patients, satisfying the predetermined sample size criteria, after two patients were removed from the specialist nursing group due to incomplete data.

Nursing protocols

Patients were divided into two groups based on the nursing model: the routine care group and the specialized nursing group. Standard PICU nursing was provided to the routine care group, which included routine observation for complications like filter clotting or tubing problems, monitoring vital signs every two hours, and modifying CRRT parameters in accordance with doctor orders.

A CRRT-specialist nurse led an organized, multidisciplinary intervention for the specialized nursing group that included the following essential elements:

(1) Multidisciplinary Team (MDT): Clinical pharmacists, dietitians, pediatric nephrologists, and certified CRRT-specialized nurses made up the core team. Psychotherapists, biomedical engineers, and infection control nurses offered assistance, guaranteeing thorough cover-

age of every facet of CRRT, from technical operation to emotional support.

(2) Collaborative Operating Mechanism: To evaluate patient data and create daily care plans, the MDT performed joint ward rounds every day. For predetermined thresholds (e.g., TMP > 200 mmHg), a critical value response system was set up that would sound an alarm and notify the team. To examine unfavorable incidents and enhance procedures, weekly quality improvement meetings were conducted.

(3) Structured Nursing Modules: Using an organized method, the specialized nursing protocol combined four essential elements. Initially, bedside ultrasonography monitoring and Pulse Index Continuous Cardiac Output (PICCO) were used to guide the implementation of precise volume management. A systematic three-step fluid resuscitation strategy was used to treat hypotension, and net ultrafiltration was dynamically adjusted using an age-specific algorithm. Second, stratified anticoagulation therapy was carried out by customizing strategies - such as argatroban, saline flushing, or localized citrate anticoagulation - according to each patient's platelet levels and bleeding risk, along with appropriate monitoring protocols. Third, a variety of strategies, such as pre-CRRT albumin infusion, the use of warmed replacement fluid, and improved catheter management to lower the risks of hypotension and catheter-related infections, were used to achieve comprehensive complication prevention. Fourth, in order to improve family engagement and treatment compliance, age-appropriate interventions like play therapy and personalized videos were used to reinforce psychological and family support. Additionally, a "CRRT Parent School" was established, and parents were supervised while participating in non-technical care tasks.

Observation measures

The incidence of treatment-related problems, such as hypotension, catheter-related bloodstream infection, and filter clogging, and the frequency of unexpected CRRT interruptions (defined as treatment pauses lasting ≥ 1 hour for non-medical causes) were the main outcomes. These records came from laboratory reports, nurse shift logs, and CRRT machine alarm logs.

The duration of CRRT overall, the length of hospital and intensive care unit stays, the time it took for renal function to return, and family satisfaction with nursing care were all considered secondary outcomes. The attainment of urine production ≥ 1 mL/kg/h for 24 consecutive hours or a decrease in serum creatinine by ≥ 50% from peak levels were considered indicators of renal recovery. The modified Newcastle Satisfaction with Nursing Scale (NSNS) was used to measure family satisfaction.

To further evaluate the systemic effects of the nursing intervention, the following biomarkers were analyzed before and after CRRT: inflammatory markers, including C-reactive protein (CRP; immunoturbidimetry) and procalcitonin (PCT; electrochemiluminescence immunoassay); as well as renal, nutritional, and hemodynamic parameters, including cystatin C (Cys-C; particle-enhanced immunoturbidimetry), albumin (ALB; bromocresol green method), and the Vasoactive-Inotropic Score (VIS). The VIS was calculated at CRRT initiation, 24 hours, 48 hours, and at the end of treatment.

All data, including demographic characteristics, laboratory results, CRRT parameters, and nursing documentation, were retrospectively retrieved from the hospital's electronic medical record system. Family satisfaction surveys were administered anonymously, achieving a 100% response rate.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) 26.0 (IBM Corp., Armonk, NY, USA) was used to conduct the statistical analyses. Numbers and percentages are used to display categorical variables. If a continuous variable is regularly distributed, it is expressed as mean ± standard deviation; if it is not, it is written as median and interquartile range. For continuous variables, the independent samples t-test or Mann-Whitney U test were used for between-group comparisons; for categorical variables, the χ^2 test or Fisher's exact test were used, depending on the situation. Measurements taken before and after treatment within the same group were compared using paired-sample t-tests. Statistical significance was defined as a two-sided P value of less than 0.05. To guarantee accuracy and consistency, two investigators independently extracted and veri-

Table 1. Baseline characteristics of patients in the two groups

Characteristics	Total (n = 140)	Specialized Nursing (n = 72)	Routine Care (n = 68)	t/χ^2	*P*
Gender (n, %)				0.086	0.770
Male	80 (57.14)	42 (58.33)	38 (55.88)		
Female	60 (42.86)	30 (41.67)	30 (44.12)		
Age (years, $\bar{x} \pm s$)	5.56 ± 2.46	5.32 ± 2.54	5.81 ± 2.37	1.178	0.241
Composition of Primary Etiologies (n, %)					
Prerenal	68 (48.57)	35 (48.61)	33 (48.53)	0.217	0.897
Renal	37 (26.43)	20 (27.78)	17 (25.00)		
Postrenal	35 (25.00)	17 (23.61)	18 (26.47)		
Severity of AKI (n, %)				0.008	0.928
Stage II	88 (62.86)	45 (62.50)	43 (63.24)		
Stage III	52 (37.14)	27 (37.50)	25 (36.76)		
SOFA	7.89 ± 1.27	7.72 ± 1.20	8.07 ± 1.32	1.643	0.103

Note: SOFA, Sequential Organ Failure Assessment.

Table 2. Comparison of unplanned CRRT interruptions between the two groups

Variable	Specialized Nursing (n = 72)	Routine Care (n = 68)	χ^2/Z	*P*
Patients with Interruptions, n (%)	18 (25.00)	58 (85.29)	51.230	< 0.001
Number of Interruptions [M (P_{25}, P_{75})]	0 (0, 1)	2 (1, 3)	8.850	< 0.001
Reasons for Interruption, n (%)				
Filter Coagulation	2 (2.78)	14 (20.59)	10.959	< 0.001
Hypotension	2 (2.78)	11 (16.18)	7.453	0.006
Tubing Disconnection	0 (0.00)	6 (8.82)	—	0.012*
Other Reasons	14 (19.44)	27 (39.71)	6.933	0.009

Note: CRRT, continuous renal replacement therapy. *P value was calculated using Fisher's exact test.

fied the data; inter-rater agreement was defined as more than a Kappa value of 0.85.

Research results

Baseline characteristics

A total of 140 pediatric AKI patients undergoing CRRT were recruited and assigned to either the normal care group (n = 68) or the specialized nursing group (n = 72). Age, gender, AKI etiology, illness severity, and SOFA scores were among the baseline clinical and demographic traits that were similar across the two groups; no statistically significant differences were found (all $P > 0.05$; **Table 1**). This demonstrates that the groups were evenly distributed at baseline, enabling a reliable comparison of later results.

Treatment efficacy and clinical outcomes

In several therapeutic categories, the specialized nursing approach showed notable benefits above standard care. The specialized nursing group had a significantly decreased incidence of unplanned CRRT interruptions ($P < 0.001$), with **Table 2** summarizing the specific causes of disruptions. Similarly, the overall complication rate was significantly reduced in the specialized nursing group ($P < 0.001$), as shown in **Table 3**.

Additionally, patients in the specialized nursing group experienced a shorter total duration of CRRT, accelerated recovery of renal function - reflected by more rapid normalization of urine output and serum creatinine levels - and significantly reduced lengths of both ICU and overall hospital stay (all $P < 0.001$; **Tables 4** and **5**).

Biomarker profiles and hemodynamic stability

Post-treatment biomarker analysis revealed more pronounced improvements in the specialized nursing group. These patients exhibited significantly greater reductions in inflamma-

Table 3. Comparison of complication rates between the two groups (n, %)

Variable	Specialized Nursing (n = 72)	Routine Care (n = 68)	χ^2	*P*
Overall Complication Rate	14 (19.44)	32 (47.06)	12.088	< 0.001
Specific Complications				
Hypotension	6 (8.33)	15 (22.06)	5.167	0.023
Infection	2 (2.78)	7 (10.29)	2.154	0.142
Filter clogging	4 (5.56)	6 (8.82)	0.178	0.673
Others	2 (2.78)	4 (5.88)	0.239	0.625

Table 4. Comparison of CRRT duration and hospital stay between the two groups ($\bar{x} \pm s$)

Variable	Total (n = 140)	Specialized Nursing (n = 72)	Routine Care (n = 68)	*t*	*P*
Total Duration of CRRT Treatment (h)	49.30 ± 3.61	46.09 ± 1.46	52.69 ± 1.40	27.271	< 0.001
ICU Stay (Day)	8.85 ± 2.35	7.25 ± 1.55	10.55 ± 1.80	11.644	< 0.001
Length of Hospital Stay (Day)	12.50 ± 1.78	10.98 ± 0.76	14.11 ± 0.92	21.996	< 0.001

Note: CRRT, continuous renal replacement therapy; ICU, intensive care unit.

Table 5. Comparison of renal function recovery time between the two groups ($\bar{x} \pm s$)

Variable	Total (n = 140)	Specialized Nursing (n = 72)	Routine Care (n = 68)	*t*	*P*
Time for Urine Volume Recovery (h)	4.45 ± 0.63	3.86 ± 0.14	5.07 ± 0.18	44.536	< 0.001
Time for Creatinine Recovery (h)	6.04 ± 0.83	5.26 ± 0.17	6.87 ± 0.20	51.417	< 0.001

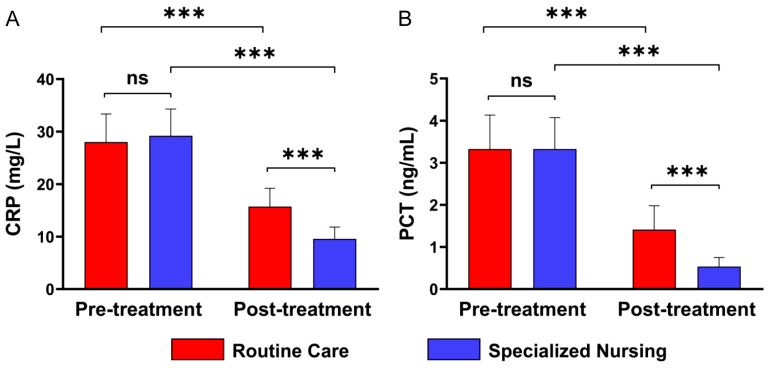

Figure 1. Comparative analysis of inflammatory marker levels between the two groups before and after CRRT. A. C-reactive protein (CRP) levels. B. Procalcitonin (PCT) levels. Data are presented as mean ± standard deviation. Intragroup comparisons (pre- vs. post-CRRT) were analyzed using the paired samples t-test. Intergroup comparisons (Specialized Nursing Intervention Group vs. Standard Care Group) at each time point were analyzed using the independent samples t-test. ns = Not significant; ***$P < 0.001$.

tory markers (CRP and PCT) and cystatin C, along with a more substantial increase in albumin levels compared to the routine care group (all $P < 0.05$; **Figures 1** and **2**).

Hemodynamic stability, assessed using the Vasoactive-Inotropic Score (VIS), was also superior in the specialized nursing group. These patients maintained significantly lower VIS values at all measured time points throughout the CRRT course ($P < 0.05$; **Figure 3**), indicating better hemodynamic control.

Family satisfaction

Family satisfaction with nursing care was significantly higher in the specialized nursing group compared to the routine care group ($P < 0.001$; **Table 6**), reflecting greater approval of the care received under the multidisciplinary specialized nursing model.

Discussion

AKI is a prevalent and potentially fatal disorder in the pediatric intensive care unit (PICU) that has a complicated etiology and a high death rate [11, 12]. This retrospective cohort study shows that in juvenile AKI patients receiving

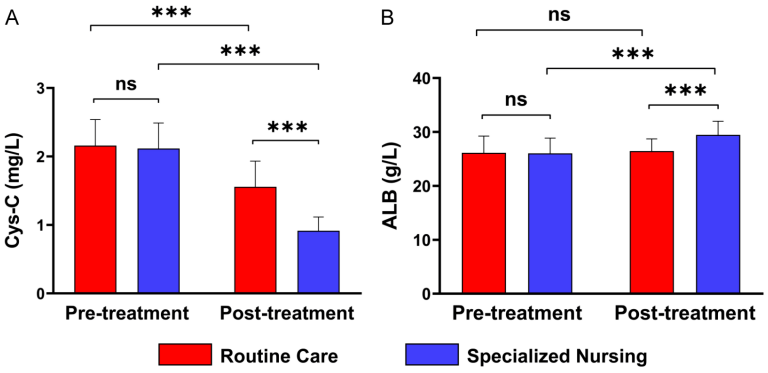

Figure 2. Comparative analysis of renal and nutritional biomarker levels between the two groups before and after CRRT. A. Cystatin C (Cys-C) levels. B. Albumin (ALB) levels. Data are presented as mean ± standard deviation. Intragroup comparisons (pre- vs. post-CRRT) were analyzed using the paired samples t-test. Intergroup comparisons (Specialized Nursing Intervention Group vs. Standard Care Group) at each time point were analyzed using the independent samples t-test. ns = Not significant; ***$P < 0.001$.

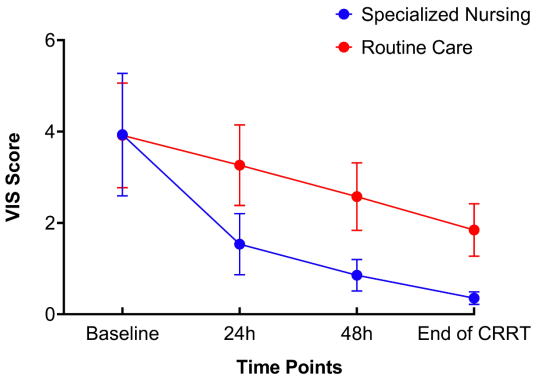

Figure 3. Comparative analysis of hemodynamic stability (assessed by Vasoactive-Inotropic Score) between the two groups at different time points during CRRT. (VIS, Vasoactive-Inotropic Score; Time Points: Baseline, Time point before the initiation of CRRT treatment; 24 h, Time point at 24 hours after the initiation of CRRT treatment; 48 h, Time point at 48 hours after the initiation of CRRT treatment; End of CRRT, Time point when CRRT treatment is completed). Error bars represent standard deviation.

CRRT, a specialized nurse intervention greatly enhances clinical care and improves important outcomes. By lowering unscheduled disruptions, minimizing procedure-related problems, accelerating the recovery of renal function, reducing hospital stays, and increasing family satisfaction, this paradigm significantly improved treatment continuity when compared to standard care. Together, these results highlight how crucial a planned, nurse-led multidisciplinary strategy is to overcoming the particular difficulties associated with pediatric CRRT and improving both the clinical prognosis and the overall course of treatment.

Effective CRRT depends on maintaining circuit patency since unforeseen disruptions impair fluid balance and solute removal [13, 14]. The specialized nursing model considerably decreased the frequency of unscheduled interruptions in this trial, especially those brought on by filter clotting and tubing disconnections. The team's protocol-driven approach, which included a stratified anticoagulation strategy tailored to dynamic bleeding risk and guided by multi-parameter monitoring [Activated Clotting Time (ACT), Activated Partial Thromboplastin Time (APTT), Transmembrane Pressure (TMP)], as well as routine saline flushing to maintain circuit integrity, is responsible for this improvement. These steps highlight the significance of combining proactive circuit maintenance with targeted anticoagulation management to improve treatment continuity and safety, and they are in line with accepted best practices for reducing circuit failure [13, 14].

During CRRT, it is essential to prevent procedure-related problems, especially hypotension and catheter-related infections, which directly jeopardize patient recovery and treatment safety [15, 16]. Our results show that a considerably lower incidence of these problems was linked to the specialized nursing paradigm. A dynamic volume management protocol that carefully titrated net ultrafiltration using real-time bedside ultrasound and hemodynamic monitoring - an approach in line with current best practices in fluid management - is probably responsible for the decrease in hypotensive episodes [15]. In line with central line-associated bloodstream infection (CLABSI) prevention guidelines, the observed decline in catheter-related infections emphasizes the need of putting in place a standardized, evidence-based catheter care bundle in the pediatric CRRT context [16]. Collectively, these outcomes underscore how a systematic, protocol-driven nursing model can enhance patient safety through improved hemodynamic and infection control.

Table 6. Comparison of family satisfaction with nursing care between the two groups ($\bar{x} \pm s$)

Variable	Total (n = 140)	Specialized Nursing (n = 72)	Routine Care (n = 68)	*t*	*P*
Nursing Quality Satisfaction Score	76.99 ± 10.48	86.29 ± 3.57	67.13 ± 4.78	26.970	< 0.001

One of the main goals of treatment for juvenile AKI is the prompt restoration of renal function, which directly affects both short-term stability and long-term results [17]. As demonstrated by a shorter CRRT duration and a quicker return of urine output and serum creatinine to normal, the specialized nursing approach considerably expedited renal recovery in this trial. Technically, the early warning system for filter clogging (TMP > 200 mmHg) helped maintain effective solute clearance, supporting the established relationship between CRRT delivery efficiency and renal recovery [17]. On a more comprehensive level, structured family involvement and psychological support reduced stress and fostered a more supportive recovery environment. By showing that active family engagement - through education and guided participation - contributes significantly to both clinical and experiential outcomes, the concurrent improvement in family satisfaction scores highlights the importance of this integrated, patient-centered strategy.

Potential causes behind the better results linked to specialist nursing were further clarified by biomarker studies. Previous evidence of CRRT-mediated clearance of inflammatory mediators in sepsis-associated AKI [18] supports the much larger reductions in CRP and PCT levels that patients in this group showed after CRRT, indicating better control of systemic inflammation. Strict catheter care and early complication management may have contributed to this anti-inflammatory impact by reducing secondary inflammatory stimuli. Similarly, a higher rise in albumin levels and a more marked decrease in cystatin C, a sensitive indicator of glomerular function, emphasize the importance of careful volume control and customized nutritional assistance in fostering renal recovery and metabolic equilibrium [19]. These results demonstrate the multidisciplinary nursing model's ability to integrate inflammatory, renal, and nutritional aspects of treatment at the same time, potentially reducing the likelihood of progression to chronic kidney disease and dampening maladaptive repair mechanisms.

Throughout CRRT, the specialized nursing group's Vasoactive-Inotropic Score (VIS) values were consistently lower, indicating improved hemodynamic stability. The unified volume management technique, which included bedside ultrasound monitoring and real-time PiCCO to guide accurate fluid titration and enable early diagnosis of hemodynamic abnormalities, is responsible for this improvement [20]. This strategy successfully decreased hypotensive episodes and the need for vasoactive support by enabling proactive control, promoting more steady CRRT supply and possibly lowering the risk of secondary organ damage [3, 21]. These results highlight how crucial structured, nurse-led hemodynamic care is to maximizing the effectiveness of CRRT and boosting physiological resilience in critically sick infants with AKI.

This study offers a methodical foundation for specialized nursing in pediatric CRRT by fusing precise, technically sophisticated nursing interventions with a multidisciplinary collaborative paradigm. Its focus on age-specific modifications for crucial factors, like volume management safety limits and anticoagulation monitoring, which take into account the distinct physiological traits of the pediatric population, is a significant contribution [22, 23]. There are however, a few restrictions to be aware of. Although sufficient for primary outcomes, the sample size restricts subgroup analysis, and the single-center, retrospective design may introduce selection bias. Furthermore, it is still unknown how the nursing treatments will affect renal function in the long run. To confirm these findings and evaluate the long-term advantages of the specialized nursing model, more multicenter prospective trials with longer follow-up are required.

Conclusion

This study concludes that for pediatric AKI patients receiving CRRT, a multidisciplinary specialized nursing model greatly enhances treatment quality and clinical results. This method provides a strong strategy for improving

prognosis in critically ill children by successfully lowering treatment interruptions, complications, and recovery time. With the potential to raise treatment standards in both primary and tertiary healthcare settings, our findings encourage the incorporation of such nurse-led, organized interventions into pediatric CRRT guidelines and clinical practice.

Acknowledgements

We acknowledge the pediatric intensive care unit staff of Hainan Women and Children's Medical Center for their clinical support and the hospital's ethics committee for approving this study.

Disclosure of conflict of interest

None.

Address correspondence to: Qiong He, Pediatric Intensive Care Unit, Hainan Women and Children's Medical Center, Haikou 571000, Hainan, The People's Republic of China. E-mail: m135198124-90@163.com

References

[1] Kaddourah A, Basu RK, Bagshaw SM and Goldstein SL; AWARE Investigators. Epidemiology of acute kidney injury in critically ill children and young adults. N Engl J Med 2017; 376: 11-20.

[2] Navaneethan SD, Zoungas S, Caramori ML, Chan JCN, Heerspink HJL, Hurst C, Liew A, Michos ED, Olowu WA, Sadusky T, Tandon N, Tuttle KR, Wanner C, Wilkens KG, Craig JC, Tunnicliffe DJ, Tonelli M, Cheung M, Earley A, Rossing P, de Boer IH and Khunti K. Diabetes management in chronic kidney disease: synopsis of the KDIGO 2022 clinical practice guideline update. Ann Intern Med 2023; 176: 381-387.

[3] Chazot G, Bitker L, Mezidi M, Chebib N, Chabert P, Chauvelot L, Folliet L, David G, Provoost J, Yonis H and Richard JC. Prevalence and risk factors of hemodynamic instability associated with preload-dependence during continuous renal replacement therapy in a prospective observational cohort of critically ill patients. Ann Intensive Care 2021; 11: 95.

[4] Deep A. Anticoagulation strategies in continuous kidney replacement therapy - does one size fit all? Pediatr Nephrol 2022; 37: 2525-2529.

[5] Lv J, Wang H, Sun B, Gao Y, Zhang Z and Pei H. Serum Albumin before CRRt was associated with the 28- and 90-day mortality of critically ill patients with acute kidney injury and treated with continuous renal replacement therapy. Front Nutr 2021; 8: 717918.

[6] de Galasso L, Emma F, Picca S, Di Nardo M, Rossetti E and Guzzo I. Continuous renal replacement therapy in children: fluid overload does not always predict mortality. Pediatr Nephrol 2015; 31: 651-659.

[7] Kes P and Basić Jukić N. New experiences with the therapy of acute kidney injury. Prilozi 2008; 29: 119-153.

[8] Daverio M, Cortina G, Jones A, Ricci Z, Demirkol D, Raymakers-Janssen P, Lion F, Camilo C, Stojanovic V, Grazioli S, Zaoral T, Masjosthusmann K, Vankessel I and Deep A; Critical Care Nephrology Section of the European Society of Paediatric and Neonatal Intensive Care. Continuous kidney replacement therapy practices in pediatric intensive care units across Europe. JAMA Netw Open 2022; 5: e2246901.

[9] Sethi S, Debiec H, Madden B, Vivarelli M, Charlesworth MC, Ravindran A, Gross L, Ulinski T, Buob D, Tran CL, Emma F, Diomedi-Camassei F, Fervenza FC and Ronco P. Semaphorin 3B-associated membranous nephropathy is a distinct type of disease predominantly present in pediatric patients. Kidney Int 2020; 98: 1253-1264.

[10] Sethi SK, Bunchman T, Chakraborty R and Raina R. Pediatric acute kidney injury: new advances in the last decade. Kidney Res Clin Pract 2021; 40: 40-51.

[11] Gupta S, Sengar GS, Meti PK, Lahoti A, Beniwal M and Kumawat M. Acute kidney injury in pediatric intensive care unit: Incidence, risk factors, and outcome. Indian J Crit Care Med 2016; 20: 526-529.

[12] Keneni M, Murugan R, Bizuwork K, Asfaw T, Tekle S, Tolosa G and Desalew A. Risk factors associated with acute kidney injury in a pediatric intensive care unit in Addis Ababa Ethiopia: case-control study. BMC Nephrol 2023; 24: 279.

[13] Rewa OG, Villeneuve PM, Lachance P, Eurich DT, Stelfox HT, Gibney RTN, Hartling L, Featherstone R and Bagshaw SM. Quality indicators of continuous renal replacement therapy (CRRT) care in critically ill patients: a systematic review. Intensive Care Med 2017; 43: 750-763.

[14] Sharma SK, Mudgal SK, Gaur R, Sharma R, Sharma M and Thakur K. Heparin flush vs. normal saline flush to maintain the patency of central venous catheter among adult patients: a systematic review and meta-analysis. J Family Med Prim Care 2019; 8: 2779-2792.

[15] Fellahi JL, Futier E, Vaisse C, Collange O, Huet O, Loriau J, Gayat E, Tavernier B, Biais M, Aseh-

noune K, Cholley B and Longrois D. Perioperative hemodynamic optimization: from guidelines to implementation - an experts' opinion paper. Ann Intensive Care 2021; 11: 58.
[16] Raina R, Mawby I, Chakraborty R, Sethi SK, Mathur K, Mahesh S and Forbes M. Acute kidney injury in COVID-19 pediatric patients in North America: analysis of the virtual pediatric systems data. PLoS One 2022; 17: e0266737.
[17] Dado DN, Ainsworth CR, Thomas SB, Huang B, Piper LC, Sams VG, Batchinsky A, Morrow BD, Basel AP, Walter RJ, Mason PE and Chung KK. Outcomes among patients treated with renal replacement therapy during extracorporeal membrane oxygenation: a single-center retrospective study. Blood Purif 2020; 49: 341-347.
[18] Wu S, Xu T, Wu C, Lei X and Tian X. Continuous renal replacement therapy in sepsis-associated acute kidney injury: effects on inflammatory mediators and coagulation function. Asian J Surg 2021; 44: 1254-1259.
[19] Zhang T, Widdop RE and Ricardo SD. Transition from acute kidney injury to chronic kidney disease: mechanisms, models, and biomarkers. Am J Physiol Renal Physiol 2024; 327: F788-F805.
[20] Naorungroj T, Prajantasen U, Sanla-ead T, Viarasilpa T and Tongyoo S. Restrictive fluid management with early de-escalation versus usual care in critically ill patients (reduce trial): a feasibility randomized controlled trial. Crit Care 2025; 29: 405.
[21] Thadani S, Silos C, Horvat C, Dolan K, Srivaths P, Fogarty T, Akcan-Arikan A, Chen J and Neyra JA. Intradialytic hypotension and hemodynamic phenotypes in children following continuous renal replacement therapy initiation. Pediatr Res 2025; [Epub ahead of print].
[22] Buccione E, Bambi S, Rasero L, Tofani L, Piazzini T, Della Pelle C, El Aoufy K, Ricci Z, Romagnoli S and Villa G. Regional citrate anticoagulation and systemic anticoagulation during pediatric continuous renal replacement therapy: a systematic literature review. J Clin Med 2022; 11: 3121.
[23] Sondhi E, Stewart M, Harper J, Konyk L, McSteen C, Crowley KL, Kim-Campbell N, Fabio A and Fuhrman DY. A comparison of the anticoagulation efficacy and safety of epoprostenol to heparin and citrate in children receiving continuous renal replacement therapy. Blood Purif 2024; 53: 838-846.