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Evaluation of Patients with Continuous Renal Replacement Therapy in a Pediatric Intensive Care Unit: A Single-center Study

Çocuk Yoğun Bakım Ünitesinde Sürekli Renal Replasman Tedavisi Uygulanan Hastaların Değerlendirilmesi: Tek Merkezli Çalışma

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Abstract

Introduction: This study aimed to evaluate the demographic and epidemiological aspects of patients who underwent continuous renal replacement therapy (CRRT) in a pediatric intensive care unit to determine the appropriate CRRT model and to reveal the factors affecting survival.

Methods: The demographic data of 85 patients who underwent CRRT in the Pediatric Intensive Care Unit of Çukurova University Faculty of Medicine Balcalı Hospital between September 2014 and January 2022 and data from 125 CRRT procedures were recorded and evaluated by statistical analysis.

Results: 52.9% of the patients were female, the mean age was 63.8±67.6 (months), and the mean body weight was 18.9±17.8 kg. The most common, underlying primary disease was nephrological (37.6%). While 88.8% of the applied CRRT procedure was continuous venovenous hemodiafiltration, 11.2% was continuous venovenous hemodialysis. Complications were observed during the procedure in 68% of the patients. In our study, unfractioned heparin was applied to 44.8% of CRRT procedures and citrate to 14.4%. The filter life of the patients treated with heparin was determined to be considerably shorter (p=0.002). It was observed that low pH and HCO_3 values and high lactate level, which are laboratory parameters obtained before CRRT, increased mortality (p=0.001, p=0.047, and p=0.001, respectively).

Conclusion: The success of CRRT treatment was thought to depend on the clinical condition of the patient, the underlying treatable disease, the control of technical problems, and the experience of the teams. In order to support the findings obtained in our study with definitive data, multicenter randomized controlled studies are required.

Keywords: Continuous renal replacement therapy, intensive care, child

Öz

Giriş: Bu çalışmanın amacı, çocuk yoğun bakım ünitesinde sürekli renal replasman tedavisi (CRRT) uygulanan hastaların demografik ve epidemiyolojik özelliklerini değerlendirmek, uygun CRRT modelini belirlemek ve sağkalımı etkileyen faktörleri ortaya koymaktır.

Yöntemler: Eylül 2014-Ocak 2022 tarihleri arasında Çukurova Üniversitesi Tıp Fakültesi Balcalı Hastanesi Çocuk Yoğun Bakım Ünitesi'nde CRRT uygulanan 85 hastaya ait demografik veriler ile toplam 125 CRRT işlemine ait veriler kaydedilmiş ve istatistiksel analizler ile değerlendirilmiştir.

Bulgular: Hastaların %52,9'u kadın olup, ortalama yaş 63,8±67,6 ay, ortalama vücut ağırlığı ise 18,9±17,8 kg idi. En sık altta yatan primer hastalık nefrolojik hastalıklar (%37,6) olarak saptandı. Uygulanan CRRT işlemlerinin %88,8'i sürekli venovenöz hemodiyafiltrasyon, %11,2'si ise sürekli venovenöz hemodiyaliz idi. Hastaların %68'inde işlem sırasında komplikasyon geliştiği gözlendi. Çalışmamızda CRRT işlemlerinin %44,8'inde unfraksiyone heparin, %14,4'ünde ise sitrat antikoagülasyonu kullanıldı. Heparin ile tedavi edilen hastalarda filtre ömrünün anlamlı derecede daha kısa olduğu belirlendi (p=0,002). CRRT öncesinde elde edilen laboratuvar parametrelerinden düşük pH ve HCO_3 değerleri ile yüksek laktat düzeyinin mortaliteyi artırdığı gözlendi (sırasıyla p=0,001, p=0,047 ve p=0,001).

Sonuç: CRRT tedavisinin başarısının; hastanın klinik durumu, altta yatan tedavi edilebilir hastalık, teknik sorunların kontrolü ve ekiplerin deneyimi ile ilişkili olduğu düşünülmektedir. Çalışmamızda elde edilen bulguların kesin verilerle desteklenebilmesi için çok merkezli randomize kontrollü çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Sürekli renal replasman tedavisi, yoğun bakım, çocuk

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Introduction

Continuous renal replacement therapy (CRRT) has become the method of choice for the treatment of critically ill children with acute kidney injury (AKI) and fluid overload over the past three decades.[1,2] The effectiveness of CRRT has increased over the years because of gradual improvements in treatment modalities and developments in technology that maintain blood flow even in hemodynamically unstable patients. Positive results, compared with more traditional dialysis methods, indicate the safety of CRRT when used in critically ill, hemodynamically unstable children. However, survival among children receiving CRRT has not increased in parallel with advances in technology.

The basic principles of CRRT are similar for adults and children. However, some adaptations need to be made for the application of CRRT to pediatric patients. Extracorporeal blood volume is particularly important for pediatric patients. Prescriptions created for adult patients need to be adapted for pediatric patients to account for their physiological needs. Providing appropriate renal replacement therapy (RRT) for pediatric patients with AKI also includes special considerations not commonly seen in the care of adult patients. The weight of pediatric patients with AKI can range from a 1.5 kg newborn to a 200 kg adult.[3] The indications for CRRT in pediatric patients are similar to those for adults. However, non-renal indications, such as congenital metabolic disorders or post-operative care of an infant with a congenital cardiac anomaly, are special conditions that may require RRT in pediatric patients.[4,5] CRRT has become the RRT modality of choice to support children with critical AKI.[6]

This study aimed to evaluate the demographic and epidemiological characteristics of patients who underwent CRRT in a pediatric intensive care unit to determine the appropriate CRRT model and identify factors affecting survival.

Materials and Methods

In this retrospective study, the demographic data for 85 patients who underwent CRRT in the Pediatric Intensive Care Unit of Çukurova University Faculty of Medicine Balcalı Hospital between September 2014 and January 2022, and data from 125 CRRT procedures were recorded. The necessary permission for the study was obtained from the Ethics Committee of Çukurova University Faculty of Medicine Non-Interventional Clinical Research (approval no: 1, date: 06.12.2019). The ethics committee reviewed our study and waived the need for informed consent because all data and samples were analyzed retrospectively and were collected as part of routine clinical practice, in accordance with current guidelines. Informed consent was not required and therefore not obtained, as the study was conducted retrospectively and involved no direct patient intervention.

Patient data were obtained from the hospital information management system and from patient files. The demographic characteristics of patients, the underlying primary disease, the reason for hospitalization in the pediatric intensive care unit, the duration of hospitalization, the pediatric mortality risk (PRISM-III) and pediatric logistic organ dysfunction (PELOD-II) scores recorded during hospitalization, the number and types of organ failure, the total CRRT duration during pediatric intensive care hospitalization, and the mortality status in the intensive care unit were recorded.

To evaluate CRRT characteristics, the indication for CRRT, the selected CRRT mode, the localization of the vascular pathway, the catheter size, and the anticoagulant method were recorded. CRRT complications, the reason for treatment termination, inotropic support during CRRT, the vasoactive inotrope score, mechanical ventilation, extracorporeal membrane oxygenation (ECMO), erythrocyte, thrombocyte, and fresh frozen plasma (FFP) support were evaluated.

Patients with complete clinical and CRRT procedure records were included in the analysis. Those with missing or incomplete medical files, nursing observation notes, or CRRT monitoring charts—particularly during periods of transition to the digital hospital record system—were excluded.

Values of blood gases, lactate, sodium, potassium, total and ionized calcium, magnesium, phosphorus, blood urea nitrogen (BUN), creatinine, uric acid, hemoglobin, and hematocrit were recorded in the patients before and after CRRT and compared between the pre- and post-treatment periods.

Statistical Analysis

The SPSS 25.0 software package was used for statistical analysis of the data. Categorical measurements were summarized as counts and percentages; continuous measurements were summarized as mean, standard deviation, median, and minimum-maximum. The distributions of continuous measurements between groups were assessed with the Shapiro-Wilk test. A paired-samples t-test was used to compare continuous measurements before and after treatment. An independent-samples t-test was used to compare continuous measurements between groups. Chi-square and Fisher's exact tests were used to compare categorical variables. The statistical significance level was set at 0.05 for all tests.

Results

Among the patients, 52.9% were female, and the mean age was 63.8±67.6 months. The mean body weight of the patients was 18.9±17.8 kg. The mean PRISM-III scores of the

patients were 11.5±9.2, while the mean PELOD-II scores were 19.6±13.6. The most frequently affected organ systems were the renal system (69.4%), the respiratory system (55.3%), and the cardiovascular system (25.9%). The mean length of stay in the intensive care unit was 11±13.2 days, while the mean hospital stay was 28.2±23.7 days. 17.6% of patients died during their intensive care stay. The patients' demographic and hospitalization data are presented in Table 1.

Table 1. Demographic data and hospitalization data

Parameters	All patients (n=85)
Gender, n (%)	
Male	40 (47.1%)
Female	45 (52.9%)
Age (month)	
Mean ± standard deviation	63.8±67.6
Median	28
Minimum-maximum	1-210
Body weight (kg)	
Mean ± standard deviation	18.9±17.8
Median	11
Minimum-maximum	3.5-90
Body weight groups, n (%)	
<10 kg	39 (45.9%)
10-20 kg	21 (2.7%)
20-50 kg	17 (20%)
>50 kg	8 (9.4%)
Admission PRISM-III score	
Mean ± standard deviation	11.5±9.2
Median	8
Minimum-maximum	1-44
Admission PELOD-II score	
Mean ± standard deviation	19.6±13.6
Median	12
Minimum-maximum	1-52
Number of organ failures (n)	
Mean ± standard deviation	2±1.1
Median	2
Minimum-maximum	1-6
Affected organ system, n (%)	
Respiratory	47 (55.3%)
Cardiovascular	22 (25.9%)
Renal	59 (69.4%)
Neurological	17 (20%)
Hematological	9 (10.6%)
Hepatic	11 (12.9%)
Intensive care hospital stay (days)	
Mean ± standard deviation	11±13.2
Median	6
Minimum-maximum	1-79
Length of hospital stay (days)	
Mean ± standard deviation	28.2±23.7
Median	20
Mean ± standard deviation	3-110
Total CRRT time (hours) during intensive care stay	
Mean ± standard deviation	42.1±47
Median	23
Minimum-maximum	3-237
Mortality in intensive care, n (%)	
No	70 (82.4%)
Yes	15 (17.6%)

PRISM-III: Pediatric mortality risk score, PELOD-II: Pediatric logistic organ dysfunction score, CRRT: Continuous renal replacement therapy

Before the start of CRRT, double-lumen catheters were placed by intensive care unit specialists. Ultrasound was used during catheter placement. Regarding CRRT access routes, 74.4% of the patients had a right jugular dialysis catheter, 10.4% had a left jugular catheter, 8.8% had a right subclavian catheter, and 6.4% had a right femoral catheter. The most commonly used dialysis catheter sizes were 7 French (F) (48%), 9F (17.6%), and 8F (16%) (Table 2).

The distribution of indications for CRRT showed that most patients initiated CRRT because of fluid overload (70.4%) or metabolic disease/severe metabolic acidosis (24%). The mean fluid load of patients who underwent CRRT for fluid overload was 9.8±4.2%. Considering the CRRT modalities applied, 88.8% of the procedures were continuous venovenous hemodiafiltration (CVVHDF), while 11.2% were continuous venovenous hemodialysis (CVVHD). In clinical practice, CVVHDF was the preferred initial modality for patients with fluid overload and metabolic indications, whereas CVVHD was reserved mainly for selected cases with predominant

Table 2. Catheter data

Parameters	All procedures (n=125)
Dialysis catheter site, n (%)	
Right jugular	93 (74.4%)
Left jugular	13 (10.4%)
Right subclavian	11 (8.8%)
Right femoral	8 (6.4%)
Dialysis catheter size, n (%)	
7F	58 (48%)
8F	20 (16%)
9F	22 (17.6%)
10F	11 (8.8%)
12F	12 (9.6%)

F: French size

azotemia or electrolyte imbalances. The mean blood flow rate was 5.7±2.2 mL/kg/min, and the mean total dialysis dose was 2396.4±679 mL/1.73 m^2/hour. The treatment data obtained from 125 CRRT procedures are summarized in Table 3.

When the laboratory parameters obtained before and after patient CRRT application were compared, it was observed that there was a notable change in the mean pH, base deficit, and HCO_3 values in the post-treatment period (p=0.001). There was no statistically significant change in lactate values before and after treatment (p=0.173). A distinct increase was observed in the mean hemoglobin values of the patients during the post-treatment period (p=0.001). Among the biochemical parameters, BUN, creatinine, and uric acid decreased markedly in the post-treatment period (p=0.001). Serum potassium, magnesium, and phosphorus levels decreased significantly in the post-treatment period (p=0.001, p=0.015, and p=0.001, respectively). Although sodium and calcium values decreased in the post-treatment period, the differences between the two periods were not statistically significant (p>0.05) (Table 4).

Complications were observed during the procedure in 68% of the patients. The most common were metabolic imbalance (47.2%), coagulation in the circuit (27.2%), and hypotension (14.4%). Among patients with metabolic imbalance,

Table 3. CRRT indications and treatment settings

Parameters	All procedures (n=125)
CRRT indication, n (%)	
Fluid load (not responding to medical treatment)	88 (70.4%)
Severe azotemia and symptomatic uremia	3 (2.4%)
Metabolic disease/severe metabolic acidosis	30 (24%)
Electrolyte disorder	2 (1.6%)
Drug intoxication	2 (1.6%)
Fluid load at initiation of CRRT (%)	
Mean ± standard deviation	9.8±4.2
Median	10
Minimum-maximum	2-25
Mode of CRRT, n (%)	
CVVHDF	111 (88.8%)
CVVHD	14 (11.2%)
Blood flow speed (mL/kg/min)	
Mean ± standard deviation	5.7±2.2
Median	5.81
Minimum-maximum	1.47-11.43
Total dialysis dose (mL/1.73 m^2)	
Mean ± standard deviation	2396.4±679
Median	2169.51
Minimum-maximum	1251.94-5476.56

CRRT: Continuous renal replacement therapy, CVVHDF: Continuous venovenous hemodiafiltration, CVVHD: Continuous venovenous hemodialysis

Table 4. Comparison of blood gas, biochemistry, hemogram, and electrolyte values with the pre- and post-treatment period of CRRT

Parameters	Before CRRT	After CRRT	p-values
pH			
Mean ± standard deviation	7.29±0.09	7.35±0.08	**0.001**
Median	7.3	7.36	
Minimum-maximum	7.05-7.51	6.9-7.5	
Base deficit (mEq/L)			
Mean ± standard deviation	-5.7±5.5	-2.4±3.7	**0.001**
Median	-4.9	-2.3	
Minimum-maximum	-23.2-4.7	-17-7	
HCO_3 (mEq/L)			
Mean ± standard deviation	18.8±4.6	21.7±3.4	**0.001**
Median	19.5	21.7	
Minimum-maximum	3-28	9-30.5	
Lactate (mmol/L)			
Mean ± standard deviation	2.6±2.9	2.3±3.3	0.173
Median	1.6	1.2	
Minimum-maximum	0.3-22	0.3-21	
Blood urea nitrogen (mg/dL)			
Mean ± standard deviation	45.1±35.1	26.2±21.1	**0.001**
Median	38	23.4	
Minimum-maximum	2.3-151.2	1-109.4	
Creatinine (mg/dL)			
Mean ± standard deviation	2.6±2.5	1.6±1.6	**0.001**
Median	1.95	1.2	
Minimum-maximum	0.16-12.14	0.04-11.3	
Uric acid (mg/dL)			
Mean ± standard deviation	7.6±4.8	4.5±2.6	**0.001**
Median	6.5	4.05	
Minimum-maximum	0.6-24	0.8-18	
Hemoglobin (g/L)			
Mean ± standard deviation	8.8±1.8	9.2±2	**0.049**
Median	8.5	9	
Minimum-maximum	5.4-14.8	6.1-22.5	
Sodium (mmol/L)			
Mean ± standard deviation	142.3±8.5	141.8±14.2	0.644
Median	141	142	
Minimum-maximum	118-178	120-162	
Potassium (mmol/L)			
Mean ± standard deviation	3.5±1	3.1±0.7	**0.001**
Median	3.2	3	
Minimum-maximum	1.7-7.2	1.7-5.5	
Total calcium (mg/dL)			
Mean ± standard deviation	9.3±1.1	9.1±1.2	0.167
Median	9.4	9.14	
Minimum-maximum	6.1-13.9	5.2-13.71	

Table 4. Continued

Parameters	Before CRRT	After CRRT	p-values
Ionized calcium (mg/dL)			
Mean ± standard deviation	1±0.2	1±0.2	0.660
Median	0.98	0.98	
Minimum-maximum	0.44-1.5	0.56-1.69	
Magnesium (mg/dL)			
Mean ± standard deviation	2.2±0.9	2±0.7	**0.015**
Median	1.97	1.82	
Minimum-maximum	0.94-7.9	1.05-6.7	
Phosphorus (mg/dL)			
Mean ± standard deviation	5.1±2.6	3.6±1.5	**0.001**
Median	4.75	3.35	
Minimum-maximum	0.62-12.4	1.1-8.1	

CRRT: Continuous renal replacement therapy

hypokalemia developed in 50.9%, hypocalcemia in 49.2%, and hypophosphatemia in 16.9%. The majority of patient treatments were terminated for completion (60.8%) and for coagulation in the circuit (30.4%) (Table 5).

No statistically significant difference in complications was observed between patients treated with heparin and those treated with citrate (p>0.05). The filter life was significantly shorter in patients treated with heparin (p=0.002) (Table 6).

Table 5. Complications, metabolic imbalance, and reasons for termination of treatment

Parameters	All procedures
Complication, n (%)	
None	40 (32%)
Bleeding	1 (0.8%)
Coagulation in the circuit	34 (27.2%)
Metabolic imbalance	59 (47.2%)
Hypotension	18 (14.4%)
Hypothermia	5 (4%)
Other complications	2 (1.6%)
Metabolic imbalance, n (%)	
Metabolic acidosis	3 (5.1%)
Hypocalcemia	29 (49.2%)
Hypokalemia	30 (50.9%)
Hypernatremia	2 (3.4%)
Hypophosphatemia	10 (16.9%)
Hypomagnesemia	5 (8.5%)
Reason for termination of treatment, n (%)	
Completion of treatment	76 (60.8%)
Coagulation in the circuit	38 (30.4%)
Catheter dysfunction	5 (4.0%)
Technical problems	1 (0.8%)
Other reasons	5 (4.0%)

When the applied treatments were examined, the rate of inotropic administration was 37.6%. The highest vasoactive-inotropic score was found to be 34.1±27.3 on average. The proportion of patients who underwent mechanical ventilation was 51.2%. The proportion of patients who underwent ECMO was 4%. 74.4% of the patients received erythrocyte suspension support, 38.4% received thrombocyte support, and 27.2% received FFP support (Table 7).

Table 6. Complications and filter life in patients treated with heparin and citrate

Parameters	Heparin (n=56)	Sitrat (n=18)	p-values
Complication, n (%)			
None	26 (46.4%)	5 (27.8%)	0.163
Bleeding	1 (1.8%)	0 (0%)	1.000
Coagulation in the circuit	12 (21.4%)	4 (22.2%)	1.000
Metabolic imbalance	23 (41.1%)	9 (50%)	0.506
Hypotension	6 (10.7%)	3 (16.7%)	0.679
Hypothermia	6 (10.7%)	3 (16.7%)	0.145
Filter life (hours)			
Mean ± standard deviation	20.6±25.7	35.8±20.1	**0.002**
Median	13	38	
Minimum-maximum	4-140	7-76	

Table 7. Applied treatments

Parameters	All procedures (n=125)
Inotropic support, n (%)	
No	78 (62.4%)
Yes	47 (37.6%)
Vasoactive inotrope score	
Mean ± standard deviation	34.1±27.3
Median	30
Minimum-maximum	1-117
Mechanical ventilation, n (%)	
No	61 (48.8%)
Non-invasive	4 (3.2%)
İnvasive	60 (48%)
Extracorporeal membrane oxygenation, n (%)	
No	120 (96%)
Yes	5 (4%)
Erythrocyte suspension support, n (%)	
No	32 (25.6%)
Yes	93 (74.4%)
Platelet support, n (%)	
No	77 (61.6%)
Yes	48 (38.4%)
Fresh frozen plasma supplement, n (%)	
No	91 (72.8%)
Yes	34 (27.2%)

Discussion

CRRT is a life-saving treatment that provides appropriate fluid management and removal of toxic substances and metabolites, especially in the care of critically ill children with AKI. CRRT has been used in pediatric patients for nearly 30 years. These new treatment options, which are under development, are also being applied in our country, but data on these applications in pediatric patients are limited both worldwide and nationally.

Patients undergoing CRRT require a vascular access route established via dialysis catheters. In the study by Symons et al.[7], of 344 patients who underwent CRRT, 73% had a femoral catheter, 16% an internal jugular catheter, and 9% a subclavian catheter. Hackbarth et al.[8] applied femoral catheters to 69% of 376 pediatric patients, internal jugular catheters to 16%, and subclavian catheters to 8%. The most common catheter sizes were 11.5 (18.9%), 8 (17.3%), and 12.5 (17%), respectively. In the study by Erkol Tuncer et al.[9], 50% of the patients had a jugular vein catheter, 36% a femoral vein catheter, and 12% a subclavian vein catheter. When we examined the dialysis catheter sites applied to the patients in our study, the most common sites for catheterization were right jugular (74.4%), left jugular (10.4%), right subclavian (8.8%), and right femoral (6.4%). The most commonly used dialysis catheter sizes were 7F (48%), 9F (17.6%), and 8F (16%).

Fluid load is one of the most common CRRT indications.[10] Flores et al.[11] found that the fluid loads of patients who died and survived were similar in pediatric patients who underwent CRRT. In this study, the mean fluid load of patients initiated on CRRT for fluid overload was approximately 12%. The study indicates that there was no relationship between mortality and fluid load.[11] In the study by Sutherland et al.[12], it was shown that patients with less fluid load before CRRT had a relatively low mortality in the other group. In our study, the mean fluid load of the patients who started CRRT with fluid load was 9.8±4.2%. The literature reports conflicting results regarding the effect of fluid load on mortality. Although some studies show that fluid load affects mortality, others, including ours, indicate that it does not.

Studies on CRRT modes for use in children are ongoing. In the study by Symons et al.[7], it was observed that 48% of the patients were treated with CVVHD, 30% with CVVHDF, and 21% with CVVHF. In a different study conducted on 376 patients, 46% of the patients were treated with CVVHD, 26% with CVVHF, and 24% with CVVHDF.[8] In the study by Askenazi al.[13], CVVHD was applied to 59.5% of the patients. In the same study, the rate of application of CVVHF was 17.9%, while the rate of application of CVVHDF was 22.6%.[13] While 88.8% of the procedures evaluated in our study were CVVHDF, 11.2% were CVVHD.

Complications were observed during 68% of CRRT procedures evaluated in our study. The most common complications were metabolic imbalance (47.2%), coagulation in the circuit (27.2%), and hypotension (14.4%). 50.9% of patients with metabolic imbalances developed hypokalemia, 49.2% hypocalcemia, and 16.9% hypophosphatemia. Schiffl[14] demonstrated that high flow rates cause more hypotension, hypokalemia and hypophosphatemia. Many large-scale studies show that CRRT patients frequently develop hypophosphatemia, hypokalemia, hypocalcemia, and hypomagnesemia.[15-18] In the study by Finkel and Podoll[19] it was shown that the most common complications were bleeding, infection, venous thrombosis, hypothermia, hypotension, and metabolic imbalances. Erkol Tuncer et al.[9] determined that 56% of the patients developed hypotension, 44% hypophosphatemia, 38% hypothermia, 32% hypokalemia, 22% bleeding, and 20% hypovolemia.

Critically ill pediatric patients receiving CRRT frequently require concurrent intensive care support, including vasoactive agents and mechanical ventilation, primarily due to underlying hemodynamic instability and multiorgan dysfunction rather than CRRT itself. Therefore, pediatric CRRT practice necessitates close hemodynamic monitoring and individualized treatment prescriptions to optimize efficacy and minimize procedure-related complications.[20] Additional treatments may be required for patients receiving CRRT. Symons et al.[7] showed that two-thirds of the patients who underwent CRRT received vasopressor therapy. In the study by Askenazi al.[13], the use of vasopressors in patients who died was 79%, while it was 64% in patients who survived, but there was no statistically significant difference between the two groups. In the study by Hayes et al.[21], the need for vasopressors in children who underwent CRRT was found to be 73.7%. Aslan et al.[10] reported a mean vasoactive inotrope score of 24. In addition, the rate of mechanical ventilation was found to be 65.4% in this study. Among the treatments applied in our study, inotropic administration occurred at a rate of 37.6%. The highest vasoactive inotrope score was found to be 34.1±27.3 on average. The rate of patients who underwent mechanical ventilation was 51.2%.

Anticoagulation plays a critical role in CRRT. In a study conducted in the United States, it was observed that 7% of the patients were not treated with anticoagulation, 56% of the patients were treated with citrate, and 37% with classical heparin.[7] Brophy et al.[22] compared anticoagulation methods in patients who underwent multicenter CRRT. Although a slight decrease was detected in the filter life of the patients in whom heparin was used among the anticoagulation methods, no statistically significant difference in filter life was observed between the two groups. In the study by Sık et al.[23] in which heparin was administered to 26 patients and coagulation with citrate during the CRRT procedure to 19 patients, it was determined

that the filter life of the patients who were administered citrate was notably longer than the patients who received heparin. In addition, no distinctive relationship was found between anticoagulation and mortality.[23] Anticoagulation was not applied in 40.8% of CRRT procedures in our study; classical heparin was applied in 44.8%, and citrate in 14.4%. No statistically significant difference in complications between patients treated with heparin and those treated with citrate was observed. The filter life of patients who received heparin was significantly shorter (p=0.002). Studies conducted in the general pediatric population indicate a relationship between citrate, one of the anticoagulation methods, and filter life.[24,25]

One measure of success for CRRT is its effect on mortality. Symons et al.[7] found the mortality rate to be 42%. This study also examined the factors affecting mortality. According to this evaluation, mortality rates increase in patients under 10 kg, under 1 year of age, and with a PRISM-II score above 10.[7] In the study by Askenazi et al.[13], the mortality rate was 57% in children under 10 kg and treated with CRRT, while it was 36% in children over 10 kg. This suggests that the child's body weight may affect mortality. Erkol Tuncer et al.[9] found the mortality rate to be 58% in patients who underwent CRRT, and patients with high urine output and low potassium levels had higher survival rates. Many other studies in the literature specify that mortality in pediatric patients undergoing CRRT varies between 30% and 70%.[26-28] Duyu and Turkozkan[29] found the mortality rate to be 29.7%. Among the factors affecting mortality in pediatric patients who underwent CRRT were underlying primary disease, multi-organ failure, low urine output, the need for mechanical ventilation, and the need for vasopressors. In our study, the mortality rate was 17.6%, and there was no meaningful relationship between mortality and CRRT. The overall mortality rate in our cohort was 17.6%, which is lower than the rates reported in many previous pediatric CRRT studies, where mortality has ranged from 30% to 70%. This relatively low mortality rate may be explained by several factors, including the early initiation of CRRT, a high proportion of patients with potentially reversible renal conditions, lower rates of ECMO support, and the accumulated experience of a specialized multidisciplinary intensive care team. These findings suggest that outcomes of CRRT may be strongly influenced by patient selection and center-specific expertise rather than the CRRT modality alone.

Study Limitations

This study has several important limitations that should be considered when interpreting the results. First, the retrospective, single-center design limits the generalizability of our findings to other pediatric intensive care units with different patient profiles, treatment protocols, and levels of experience with CRRT. Second, although the overall sample size was acceptable for a single-center study, some subgroups—particularly patients receiving citrate anticoagulation—were relatively small, which may have reduced the statistical power to detect differences in complications and outcomes between anticoagulation strategies. Third, due to the retrospective nature of data collection, the timing of CRRT initiation, fluid overload trajectories, and clinical decision-making processes could not be fully standardized or analyzed in detail. Fourth, although several laboratory parameters obtained before CRRT initiation were associated with mortality, comprehensive multivariable analyses were limited, and residual confounding by disease severity, organ dysfunction, and supportive therapies cannot be excluded. Another limitation of the study, in terms of statistical analysis, was that no multivariable regression analysis was performed because the limited number of mortality events in our cohort could have resulted in model overfitting and unreliable estimates. Therefore, odds ratios with 95% confidence intervals could not be reported. Finally, long-term renal outcomes and post-intensive care follow-up data were unavailable, preventing assessment of renal recovery and long-term morbidity. Despite these limitations, our study provides valuable real-world data on CRRT practices and outcomes in a pediatric intensive care unit and contributes to the limited body of national and international literature on this subject.

CRRT is a life-saving method in children with AKI and fluid overload. The success of this treatment depends on the clinical condition of the patient, the underlying treatable disease, the management of technical problems, and the teams' experience. CRRT is an important extracorporeal treatment and life-saving procedure in intensive care units. To confirm the findings of our study, multicenter randomized controlled trials are required.

Conclusion

CRRT remains a vital supportive therapy for critically ill children with AKI and fluid overload. While technological advances have improved the feasibility and safety of CRRT, patient-related factors and center experience continue to play a major role in determining outcomes. Multicenter prospective studies are needed to further clarify optimal timing, dosing, and anticoagulation strategies in pediatric CRRT.

Ethics

Ethics Committee Approval: The necessary permission for the study was obtained from the Ethics Committee of Çukurova University Faculty of Medicine Non-Interventional Clinical Research (approval no: 1, date: 06.12.2019).

Informed Consent: Informed consent was not required and therefore not obtained, as the study was conducted retrospectively and involved no direct patient intervention.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.E., A.Y., Concept: D.Y., Ö.Ö.H., A.K.B., Design: D.Y., Ö.Ö.H., A.K.B., Data Collection or Processing: A.E., A.Y., Analysis or Interpretation: D.Y., F.E., A.Y., A.K.B., Literature Search: A.E., A.Y., Writing: A.E.

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