ORIGINAL RESEARCH

# Enhancing Quality Control in Continuous Renal Replacement Therapy Through ICU Specialist Nursing Care Management Program

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## ABSTRACT

**Objective •** This study aims to investigate the impact of a specialized intensive care unit (ICU) nursing quality control team management program on continuous renal replacement therapy (CRRT). Our goal is to provide insights for enhancing the clinical outcomes of CRRT and improving patient satisfaction.

**Methods •** We conducted this study at The First People's Hospital of Linping District in Hangzhou, China, from January 2018 to December 2021. The study comprised 519 critically ill patients in need of CRRT. Among them, 265 patients received routine bedside care management for CRRT (control group), while 254 patients received specialized quality control management for CRRT (experimental group). We compared several key parameters between the two groups, including the unplanned downtime rate, average downtime duration, compliance with continuous treatment for >24 hours and scheduled downtime for 72 hours, daily hemodialysis cost per patient, duration of single filter usage, unplanned extubation rate, and incidence of catheter-associated bloodstream infections. Additionally, we assessed nursing satisfaction, blood biochemical markers, and coagulation indices for both groups.

**Results •** Compared to the control group, the experimental group demonstrated a reduced occurrence of unplanned events, an increase in average downtime duration, greater compliance with continuous treatment (>24 hours) and scheduled downtime (72 hours), lower daily hemodialysis costs per patient, extended duration of single filter usage, reduced rates of unplanned extubation and catheter-related bloodstream infections. Furthermore, patients in the experimental group reported significantly higher nursing satisfaction. In terms of blood potassium, sodium, BUN, and SCr levels, the experimental group exhibited lower values compared to the control group. In the investigation of blood coagulation indices, the numerical values for patients in the experimental group were notably better than those in the control group.

**Conclusions •** The ICU specialized nursing quality control team management program for continuous renal replacement therapy outperforms conventional nursing management. (*Altern Ther Health Med.* [E-pub ahead of print.])


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## INTRODUCTION

Continuous Renal Replacement Therapy (CRRT) is defined as a continuous blood purification therapy administered around the clock, typically for 24 hours a day or nearly continuously. It encompasses various methods aimed at substituting impaired kidney function and gradually eliminating excess water and solutes from the body.[1] In recent years, advances in medical technology have expanded the applications of CRRT to include organ support and the management of acute and critical conditions.[2]

During bedside CRRT treatment for patients in the Intensive Care Unit (ICU), complications such as extracorporeal circulation and coagulopathy often arise due to the intricate nature of disease conditions and coagulation disorders. Additionally, unplanned discontinuation frequently presents a common challenge in the administration of CRRT within the ICU setting.[3,4] As key contributors to the CRRT process, the nursing quality of healthcare professionals plays a crucial role in influencing the unplanned downtime rate.[5] Frequent unplanned downtime can escalate treatment costs, reduce therapeutic outcomes for patients, and ultimately impose greater burdens on patients' families.[6]

Limited studies have explored the efficacy of the ICU specialist quality control team in managing bedside CRRT.

Based on our hospital's experience with critically ill patients undergoing bedside CRRT and insights provided by our medical staff, we have identified several challenges in the practice of bedside CRRT. These issues persist despite efforts to adhere to evidence-based nursing principles. Significant issues comprise the absence of standardized operating procedures for medical staff, specifically in relation to anticoagulant protocols. Furthermore, there is a notable absence of a structured training program for nurses and an established mechanism for assessing their skills.

It is critically important to establish practical and specific operational protocols to effectively address the quality issues associated with CRRT and significantly reduce the likelihood of adverse medical events. Therefore, this study aims to assess the ICU specialist quality control team's effectiveness in managing CRRT patients and to propose novel approaches for enhancing the clinical outcomes of CRRT and patient satisfaction.

## MATERIAL AND METHODS

### Study Design

We included a total of 519 critically ill patients who underwent CRRT treatment at the ICU of The First People's Hospital of Linping District in Hangzhou, China, between January 2018 and December 2021. Patients were divided into two groups based on their nursing management methods. The control group (265 cases) received routine bedside CRRT nursing management, while the experimental group (254 cases) received bedside CRRT nursing combined with specialist quality control team management. This study has received approval from the Ethics Committee of The First People's Hospital of Linping District, and all enrolled patients provided written informed consent (Registration Number: 16131/2018/ICU/RE/11.01.2018).

### Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) age greater than 18 years; (2) requiring bedside CRRT; (3) ICU stay duration exceeding 48 hours; and (4) voluntary consent provided by the patient. Exclusion criteria were as follows: (1) incomplete clinical data; (2) pregnancy or lactation; (3) presence of malignant tumors; (4) inability to tolerate CRRT therapy.

### Nursing Care in the Control Group

The control group received conventional nursing care. Supervisors, guided by medical professionals and their own expertise, administered comprehensive care before, during, and after the initiation of CRRT. This care included close monitoring of vital sign fluctuations, oversight of equipment operation, vascular access maintenance, fluid management, and the management of potential complications.

### Experimental Group and ICU Specialized Nursing Quality Control Team

In the experimental group, the treatment approach involved the utilization of CRRT alongside the ICU specialized nursing quality control team management program.

**Formation of the ICU Bedside CRRT Specialist Nursing Quality Control Team.** The ICU Nursing Quality Control Team within the experimental group was structured to comprise key roles, including a team leader, technical support staff, and team members. The responsibilities within this team were delineated as follows: (1) Team Leader: The team leader held the position of ICU head nurse, responsible for overseeing coordination and communication across all facets and managing the team's activities. The deputy head nurse of the ICU held the role of the teaching group leader, focusing on instructing and supervising team members. Additionally, an instrument manager took charge of CRRT machine quality control and maintenance. The department's director provided essential technical support and guidance, supported by two attending physicians.

(2) Team Members: The team consisted of 12 dedicated members, encompassing a deputy chief nurse, seven senior chief nurses, and one intensive care unit specialist nurse. They collectively executed specific nursing tasks. These tasks were developed based on a comprehensive review of procedures, standards, guidelines, expert consensus, and relevant literature pertaining to bedside CRRT treatment. Specialized care protocols for ICU patients undergoing bedside CRRT were established, accounting for the unique characteristics of critically ill patients.

**CRRT Nursing Protocols and Safety Objectives.** The specialist quality control management team focused on formulating comprehensive CRRT nursing protocols and safety management objectives. These protocols were designed based on the practical experiences within our department and the collective nursing expertise of our medical staff. The key components included the following: (1) ICU temporary hemodialysis tube placement process: This process was developed to ensure the proper placement of temporary hemodialysis tubes in the ICU setting; (2) Bedside CRRT treatment and nursing record sheet: A meticulous record sheet was designed to capture essential details during bedside CRRT treatment, facilitating comprehensive and accurate documentation (3) Bedside CRRT loading and unloading operation flow: This workflow outlined the procedures for the safe loading and unloading of CRRT equipment at the bedside.

These protocols addressed several critical aspects: (1) Doctor's order sheet: we ensured the availability of clear and precise doctor's orders for CRRT procedures; (2) CRRT standardized process: A defined a standardized approach for the implementation of CRRT, ensuring consistency in care delivery; (3) Monitoring methods for CRRT catheter infections: We established robust methods for monitoring and preventing catheter-related infections during CRRT; (4) Adherence to planned CRRT: We ensured that CRRT was administered according to the prescribed treatment plan; (5) Identification of CRRT-related adverse events: Monitored and documented any adverse events associated with CRRT treatment. These protocols and objectives were developed to enhance the quality of care, promote patient safety, and maintain adherence to established medical standards.

**Standardization of Bedside CRRT Anticoagulation Program.** A critical aspect of CRRT nursing is to prevent the occurrence of clotting during cardiopulmonary bypass (CPB). In our efforts to mitigate or eliminate such occurrences, the ICU quality control team extensively researched CRRT anticoagulation literature. Subsequently, we refined and standardized the original CRRT anticoagulation program, diligently implementing it. We also organized the broader medical staff to familiarize themselves with and put into practice the relevant procedures.

The most notable distinction between this revised program and the original one lies in the collaborative development of the anticoagulation plan for patients. Instead of doctors making decisions based solely on their experience, the new approach involves doctors working in partnership with the quality control team. This collaborative process is tailored to the specific conditions of each patient.

**Technical Support, Quality Control, and Emergency Management by the Specialist Quality Control Management Team.** This process includes the following key aspects: (1) Supervision of catheterization process: The team supervised the catheterization process conducted by doctors to ensure adherence to established specifications; (2) Monitoring of standardized installation and prefilling procedures: The team closely observed whether medical staff strictly adhered to the standardized processes during installation and prefilling; (3) Emergency Response: In addition to overseeing the work processes, team members were prepared to handle emergencies. If any issue arose that couldn't be resolved immediately, it was subject to further discussion and analysis by team members. This collaborative approach aimed to facilitate effective and safe resolution of the situation.

### CRRT Treatment

Puncture was performed with Baxter, Faison, or Campbell blood filters after local femoral vein anesthesia. A 12 Fr single-needle, double-lumen catheter was utilized for catheter insertion to establish temporary vascular access. The treatment modes for CRRT included CVVH (Continuous Veno-Venous Hemofiltration), CVVHD (Continuous Veno-Venous Hemodialysis), or CVVHDF (Continuous Veno-Venous Hemodiafiltration). In the treatment process, a dedicated CRRT finished liquid of 4000mL was used as the replacement fluid.

### Observational Indicators

Patient data during CRRT treatment were carefully recorded in an exclusive CRRT registration form for each patient. The recorded contents included the following indicators.

**Patient Information.** We recorded general details about patients, including key patient details such as demographics, medical history, age, and gender. We also recorded CRRT several performance metrics: The following data points are monitored and recorded: (1) Frequency of unplanned treatment interruptions; (2) Mean duration of unplanned downtime incidents; (3) Adherence to continuous treatment for over 24 hours; (4) Verification of adherence to the 72-hour scheduled downtime as outlined in the treatment plan; (5) Calculation of the daily cost associated with hemodialysis; (6) Recording the typical length of time a single filter is employed; (7) Monitoring instances of unplanned extubation during treatment; (8) Documentation of cases involving bloodstream infections associated with catheter use.

**Nursing Satisfaction Assessment.** To evaluate nursing satisfaction, a specific nursing satisfaction questionnaire was administered to patients. Patients were given instructions to complete the questionnaire on-site. In cases where the patient was unconscious or unable to respond, family members were encouraged to provide answers on their behalf. The questionnaire employed a scoring system ranging from 0 to 10 points. Scores are categorized into three distinct levels: (1) Unsatisfied (0~3 points): Indicating low levels of satisfaction; (2) Relatively Satisfied (4~6 points): Denoting moderate satisfaction; (3) Very Satisfied (7~10 points): Reflecting high levels of satisfaction.

**Laboratory Measurements.** We also compared various patient health indicators. These included blood potassium levels, blood sodium levels, blood urea nitrogen (BUN) levels, and serum creatinine (SCr) levels. Additionally, changes in blood clotting function indicators among patients were examined.

### Statistical Analysis

In this study, we utilized SPSS 25.0 software to conduct statistical analysis of the data. Continuous variables were subject to different treatments depending on their distribution:If the data conformed to a normal distribution, we employed parametric tests and presented the results as mean ± standard deviation ($\bar{x} \pm s$).For variables that did not follow a normal distribution, non-parametric tests were employed, and results were expressed as median (quartile, IQR). Categorical variables were analyzed by calculating the percentage of patients within each category, represented as [n (%)]. To compare clinical features and outcomes between groups, we employed Chi-square tests ($\chi^2$), Fisher's tests, and nonparametric tests, as appropriate. A significance level of $P < .05$ was used to establish statistical significance.

## RESULTS

### Comparison of General Data Between the Two Groups

We conducted a comparative analysis of the general clinical data between the included control group and the experimental group. We observed that there was no statistically significant difference in the basic clinical characteristics of the two patient groups ($P > .05$), refer to Table 1.

### Comparison of CRRT Treatment Effectiveness Between Groups

When assessing the effectiveness of CRRT treatment, we compared the experimental group to the control group. The

**Table 1.** Comparison of General Data Between the Two Groups

| Characteristics | Control Group (n = 265) | Experimental Group (n=254) | $t/\chi^2$ Value | *P* value |
|---|---|---|---|---|
| Age (years, $\bar{x} \pm s$) | 60±15 | 52±18 | 1.247 | .625 |
| Gender [n, (%)] | | | 0.008 | .930 |
| Male | 120 (45.3) | 116 (45.7) | | |
| Female | 145 (54.7) | 138 (54.3) | | |
| Clinical Diagnosis [n (%)] | | | 5.102 | .277 |
| Renal Failure | 103 (38.9) | 94 (37.0) | | |
| Multiple Injury | 68 (25.6) | 54 (21.3) | | |
| Poisoning | 5 (1.9) | 6 (2.4) | | |
| Septic Shock | 43 (16.2) | 60 (23.6) | | |
| CPR (Cardio-Pulmonary Resuscitation) | 46 (17.4) | 40 (15.7) | | |

**Table 2.** Comparison of CRRT Treatment Evaluation Indexes Between Groups

| Index | Control Group (n = 265) | Experimental Group (n = 254) | $t/\chi^2$ Value | *P* value |
|---|---|---|---|---|
| Unplanned Down Rate [n (%)] | 153 (42.6) | 109 (28.8) | 11.399 | .001[a] |
| 72 Hours Up to Standard Scheduled Down Rate [n (%)] | 31 (8.6) | 63 (16.7) | 15.018 | <.001[b] |
| Ccontinuous Treatment>24 Hours Up to Standard Rate [n (%)] | 147 (55.5) | 189 (69.0) | 20.376 | <.001[b] |
| Unplanned Extubation Rate [n (%)] | 31 (12.8) | 5 (1.9) | 19.091 | <.001[b] |
| Incidence of Catheter-Associated Bloodstream Infections [n (%)] | 18 (6.8) | 2 (0.7) | 12.623 | <.001[b] |
| Average Time of Unplanned Down Rate (h) | 15.71±7.33 | 20.91±11.21 | 7.021 | .004[a] |
| Average Use Time of A Single Filter (h) | 25.84±7.62 | 39.8±9.47 | 3.647 | .007[a] |
| Average Daily Hemodialysis Cost of Patients (Yuan) | 3508.3±423.22 | 2947.3±231.22 | 6.521 | .005[a] |

[a]$P < .01$
[b]$P < .001$

**Table 3.** Comparison of Nursing Satisfaction Between Two Groups of Patients.

| Groups | n | Quite Satisfied | More Satisfied | Dissatisfied | Degree of Satisfaction |
|---|---|---|---|---|---|
| Experimental Group [n (%)] | 254 | 182 (71.7) | 54 (21.3) | 18 (7.1) | 236 (92.9) |
| Control Group [n (%)] | 265 | 154 (58.1) | 45 (17.0) | 66 (24.9) | 199 (75.1) |
| $\chi^2$ | | | | | 24.501 |
| *P* value | | | | | <.05 |

Note: The $\chi^2$ value for the comparison was 24.501, and the $P < .05$, indicating statistical significance.

**Table 4.** Comparison of Therapeutic Index Results Between The Two Groups.

| Groups | n | Serum Potassium (mmol/L) | Serum Sodium (mmol/L) | SCr (umol/L) | BUN (mmol/L) |
|---|---|---|---|---|---|
| Control Group | 265 | 4.67±0.12 | 142.61±4.56 | 158.73±18.62 | 10.43±1.58 |
| Experimental Group | 254 | 3.98±0.08 | 134.78±4.13 | 112.54±11.62 | 7.96±1.36 |
| *t* | | 2.798 | 13.542 | 4.982 | 4.547 |
| *P* value | | <.05 | <.05 | <.05 | <.05 |

Note: Table 4 provides a comparison of therapeutic index results between the two groups of patients.

**Abbreviations**: SCr, serum creatinine; BUN, blood urea nitrogen.

**Table 5.** Comparison of Improvement of Coagulation Index After Nursing Between Two groups.

| Groups | n | Prothrombin Time | Activated Partial Thromboplastin Time | Thrombin Time |
|---|---|---|---|---|
| Control Group | 265 | 10.35±1.67 | 26.48±3.18 | 14.92±1.43 |
| Experimental Group | 254 | 15.74±1.23 | 36.23±2.78 | 21.63±1.87 |
| *t* | | 3.948 | 8.379 | 6.216 |
| *P* value | | .009 | | .008 |

Note: Table 5 presents a comparison of the improvement of the coagulation index between the two groups of patients.

results indicated that the experimental group exhibited significant improvements in multiple key indicators when compared to the control group. Specifically, the experimental group exhibited a decrease in unplanned downtime rate, unplanned extubation rate, the incidence of catheter-related bloodstream infections, and the average daily hemodialysis cost ($P < .05$), refer to Table 2. Conversely, certain indicators showed an increase in the experimental group, including the 72-hour standard scheduled downtime rate, continuous treatment exceeding 24 hours at the standard rate, the average duration of unplanned downtime, and the average usage time of a single filter ($P < .05$); refer to Table 2.

### Comparison of Nursing Satisfaction Between the Two Patient Groups

Nursing satisfaction within the experimental group reached 92.9% (236/254), which was notably higher than the control group's 75.10% (199/265). This difference was statistically significant ($P < .05$). Refer to Table 3.

### Comparison of Therapeutic Indices Between the Two Groups

Within the experimental group, the biochemical indices of blood potassium, blood sodium, BUN, and SCr were lower in comparison to the control group, and these differences were statistically significant ($P < .05$); refer to Table 4.

### Comparison of Coagulation Index Improvement Between the Two Groups

The comparison of coagulation indexes revealed that the values within the observation group were significantly superior to those in the control group. This disparity was statistically significant ($P < .05$); refer to Table 5.

## DISCUSSION

The utilization of CRRT plays an important role in enhancing the therapeutic outcomes and prognoses of ICU patients. However, current studies have indicated[7] that numerous factors can contribute to unplanned withdrawal incidents during the execution of CRRT. These events not only substantially impact the therapeutic efficacy for patients but also impose heightened psychological and economic burdens on both patients and their families.

The ICU quality control nursing team must prioritize addressing these issues during their work processes. Therefore, this study assessed the impact of the ICU care quality control team on patients undergoing CRRT. Following data collection and analysis, our findings indicate that the management plan implemented by the ICU specialized nursing quality control team contributes significantly to patient rehabilitation and the standardization of CRRT procedures.

The management plans devised by the ICU specialized nursing quality control team in this study included several key components: (1) The development and implementation of a standardized catheterization procedure[8] aimed at reducing

high-frequency machine alarms caused by improper positioning and blood flow blockages during catheterization. (2) The formulation of a standardized process for CRRT anticoagulant usage by medical staff,[9] effectively mitigating filter alarms and potential unplanned clotting due to anticoagulant deficiencies. (3) Rigorous training and instruction were provided to quality control team members. They placed a strong emphasis on the proper boarding and disembarkation procedures during CRRT treatment, leading to a significant reduction in unplanned disconnection events caused by the medical staff's lack of machine operation proficiency.

In general, there are two preconditions for the occurrence of catheter-related bloodstream infections. One is external, involving factors such as the catheterization environment, the entire catheterization procedure, the technical proficiency of the performer, the catheterization site, and the method of tube sealing. The other is internal, and typically, only external factors can be controlled. In practice, effectively reducing the occurrence of external risk factors alone can fulfill the requirement of decreasing the incidence of catheter-related bloodstream infection (CRBSI) during catheterization.[10-12]

In this context, the study conducted tests and gathered data on the management plan implemented by the CRRT specialist quality control team. The results of the data analysis affirmed that the implementation of this management plan effectively reduces the incidence of catheter-related bloodstream infections in patients requiring hemodialysis [10-11]. Furthermore, the collected data also demonstrated that the quality control team's management plan ensures the adherence of medical staff to technical specifications during the catheterization process. This includes supervising the implementation of hand hygiene and skin disinfection protocols and ensuring the establishment of a maximum sterile barrier during catheterization procedures.

The operational guidelines of the quality control team suggested that puncture guided by B-ultrasound can not only effectively shorten the puncture duration but also enhance the success rate of each puncture. Our medical staff strictly adhered to this protocol, it significantly reduced the possibility of bacterial invasion into the patient's body and effectively lowers the infection rate. These data analysis results align with previous research findings.[13-15]

Additionally, the enhanced management plan implemented by the specialized quality control team outlines rigorous procedures for medical staff during both onboarding and offboarding. It included the disinfection method for the catheter interface, which effectively mitigates a series of infection incidents resulting from inadequate catheter interface disinfection, consequently reducing the patient infection rate.

Most patients undergoing CRRT treatment require hemodialysis. As part of the specialized quality control team's management plan, comprehensive and standardized training was provided to medical staff, with a particular emphasis on nurses. This training ensured their proficiency in correctly using hemodialysis catheters during actual procedures and conducting subsequent catheter maintenance. This approach reduced the risk of thrombosis in the hemodialysis tube, maintained catheter patency, and minimized the likelihood of catheter infection.[16]

The operational guidance provided by the quality control team to medical staff also incorporates the practice of puncture under B-ultrasound positioning. This approach served to reduce iatrogenic extubation incidents resulting from incorrect tube placement and improper selection of blood vessels.[17-18] These findings centered on the quality control and management aspects during the implementation of CRRT treatment within the specialty's quality control team's management plan. All these strategies effectively prevented unplanned extubation incidents that could have arisen from inadequate medical care.

The specialized nursing team standardized the process of placing dialysis catheters to enhance performance and reduce unnecessary downtime due to catheter malfunction. They also established standardized anticoagulation protocols to minimize downtime caused by circuit clotting and provided standardized training, overseen by the quality control team, to set up machines and prevent unnecessary interruptions in care.

Furthermore, in the experimental group of this study, patients exhibited well-controlled serum creatinine, urea nitrogen, blood potassium, sodium, and other indicators. These findings further highlight that the ICU care quality control team's management program not only ensures the effectiveness of CRRT but also effectively removes harmful substances, ensuring the anticoagulant effect. This approach has significant implications for improving nursing quality, enhancing family satisfaction, and fostering a stable and positive nurse-patient relationship.[19-20]

The management approach employed by the nursing quality control group is innovative and focuses on optimizing the CRRT treatment process. Our findings indicate that this approach ensures alignment between the managers' and their subordinates' work outcomes and the original plan. It effectively identifies and addresses any deviations during implementation, ultimately leading to the successful achievement of management objectives throughout the treatment process.

Specialized nursing care resulted in several positive changes. These included fewer unexpected interruptions during continuous dialysis due to improved access placement and a reduced risk of accidental access loss. Dialysis was also less frequently interrupted by circuit clotting due to the use of protocol-based anticoagulation. Patients experienced better biochemical outcomes because they received more continuous dialysis with fewer unexpected interruptions, leading to fewer incidents of line and bloodstream infections. Additionally, the cost of dialysis decreased due to improved dialysis efficiency and material usage within the specialty care group. Finally, nursing satisfaction was observed to improve as a result of collaboration with unit CRRT specialists.

**Study Limitations**

It is important to acknowledge certain limitations in our study. Firstly, this study was conducted at a single medical facility, which may limit the generalizability of our findings

to other healthcare settings. Secondly, the nature of our analysis may introduce inherent biases and potential confounding variables that were not accounted for. Additionally, the relatively short duration of the study may not capture long-term effects or variations in patient outcomes over an extended period. Furthermore, the study did not consider the specific details of patient demographics or comorbidities, which could influence the observed results. Lastly, as with any healthcare intervention, there may be variations in the implementation of specialized nursing care across different healthcare institutions, which could impact the reproducibility of our findings. Further research is warranted to confirm and expand upon these findings in diverse clinical settings.

## CONCLUSION

In conclusion, our study demonstrated that the implementation of an ICU-specialized nursing quality control team management program for continuous renal replacement therapy exceeds conventional nursing management in delivering enhanced patient care. This program effectively reinforces the quality management of CRRT nursing, monitoring critical aspects such as catheterization evaluation, site selection, and the overall process execution by medical staff. It significantly improves the quality of care provided, ensuring that patients achieve optimal therapeutic outcomes. The findings of this study emphasize the clinical relevance and applicability of this specialized nursing approach, highlighting its potential to elevate the standards of care in the context of continuous renal replacement therapy.

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All authors listed in this manuscript have made substantial scientific contributions to the research and have provided their approval for its content and claims. We acknowledge the collective effort of all individuals who played a pivotal role in this study, emphasizing the importance of recognizing those who contributed significantly to the research endeavor.

### ETHICAL STATEMENT

This study has received ethical approval from the Ethics Committee of our hospital. All patients included in this study provided written informed consent, as indicated by Reg. No. 16131/2018/ICU/RE/11.01.2018.

### PATIENT CONSENT FOR PUBLICATION

We affirm that we have obtained patient consent for the publication of this research study from all individuals who participated in the investigation.

### AUTHORS' CONTRIBUTIONS

Yun Chen and Haiyan Zhou conducted the data analysis and contributed by drafting the initial manuscript. Shunbo Xu conceptualized the study and revised and finalizing the manuscript.

### DATA AVAILABILITY

The data used to support this study are available from the corresponding author upon request.

### CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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### REFERENCES

1. Tandukar S, Palevsky PM. Continuous Renal Replacement Therapy: Who, When, Why, and How. *Chest*. 2019;155(3):626-638. doi:10.1016/j.chest.2018.09.004
2. Ronco C, Reis T. Continuous renal replacement therapy and extended indications. *Semin Dial*. 2021;34(6):550-560. doi:10.1111/sdi.12963
3. Legrand M, Tolwani A. Anticoagulation strategies in continuous renal replacement therapy. *Semin Dial*. 2021;34(6):416-422. doi:10.1111/sdi.12959
4. Claure-Del Granado R, Clark WR. Continuous renal replacement therapy principles. *Semin Dial*. 2021;34(6):398-405. doi:10.1111/sdi.12967
5. Kovvuru K, Velez JCQ. Complications associated with continuous renal replacement therapy. *Semin Dial*. 2021;34(6):489-494. doi:10.1111/sdi.12970
6. See E, Ronco C, Bellomo R. The future of continuous renal replacement therapy. *Semin Dial*. 2021;34(6):576-585. doi:10.1111/sdi.12961
7. Lemarie P, Husser Vidal S, Gergaud S, et al. High-Fidelity Simulation Nurse Training Reduces Unplanned Interruption of Continuous Renal Replacement Therapy Sessions in Critically Ill Patients: The SimHeR Randomized Controlled Trial. *Anesth Analg*. 2019;129(1):121-128. doi:10.1213/ANE.0000000000003581
8. Joannes-Boyau O, Velly L, Ichai C. Optimizing continuous renal replacement therapy in the ICU: a team strategy. *Curr Opin Crit Care*. 2018;24(6):476-482. doi:10.1097/MCC.0000000000000564
9. Singh S. Anticoagulation during Renal Replacement Therapy. *Indian J Crit Care Med*. 2020;24(S3)(suppl 3):S112-S116. doi:10.5005/jp-journals-10071-23412
10. Juncos LA, Chandrashekar K, Karakala N, Baldwin I. Vascular access, membranes and circuit for CRRT. *Semin Dial*. 2021;34(6):406-415. doi:10.1111/sdi.12977
11. Lu Z, Hong Y, Tian Y, Zhang L, Li Y. The Effectiveness of a Specialized Nursing Team Intervention in the Unplanned Interruption of Continuous Renal Replacement Therapy. *Iran J Public Health*. 2022;51(3):544-551. doi:10.18502/ijph.v51i3.8930
12. Murugan R, Ostermann M, Peng Z, et al. Net Ultrafiltration Prescription and Practice Among Critically Ill Patients Receiving Renal Replacement Therapy: A Multinational Survey of Critical Care Practitioners. *Crit Care Med*. 2020;48(2):e87-e97. doi:10.1097/CCM.0000000000004092
13. Hsu HT, Chiang YC, Lai YH, Lin LY, Hsieh HF, Chen JL. Effectiveness of Multidisciplinary Care for Chronic Kidney Disease: A Systematic Review. *Worldviews Evid Based Nurs*. 2021;18(1):33-41. doi:10.1111/wvn.12483
14. Prendin A, Marinelli E, Marinetto A, et al. Paediatric nursing management of renal replacement therapy: intensive care nursing or dialysis nursing? *Nurs Crit Care*. 2021;26(6):510-516. doi:10.1111/nicc.12576
15. Odom B, Elliott S, Barrios CG; Promoting Patient and Nurse Safety in Acute Dialysis Units Through Advocacy and Collaboration. Promoting Patient and Nurse Safety in Acute Dialysis Units Through Advocacy and Collaboration. *Nephrol Nurs J*. 2021;48(2):155-167. doi:10.37526/1526-744X.2021.48.2.155
16. Baldwin I, Todd S. Therapeutic plasma exchange in the intensive care unit and with the critically ill, a focus on clinical nursing considerations. *J Clin Apher*. 2022;37(4):397-404. doi:10.1002/jca.21984
17. See EJ, Bellomo R. How I prescribe continuous renal replacement therapy. *Crit Care*. 2021;25(1):1. doi:10.1186/s13054-020-03448-7
18. Ostermann M, Lumlertgul N, Mehta R. Nutritional assessment and support during continuous renal replacement therapy. *Semin Dial*. 2021;34(6):449-456. doi:10.1111/sdi.12973
19. Roe NA, Wiss AL, Volgas S, Hudson JQ. Review of Anticoagulation in Continuous Renal Replacement Therapy. *Crit. Care Nurs. Q.* 2022; 45(2): 1 44-155. doi:10.1097/CNQ.0000000000000397
20. Bianchi NA, Altarelli M, Eckert P, Schneider AG. Complications of Regional Citrate Anticoagulation for Continuous Renal Replacement Therapy: An Observational Study. *Blood Purif*. 2020;49(5):567-575. doi:10.1159/000506253