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Evaluation of the Tolerability and Efficacy of the Main Hemodialysis Techniques in Intensive Care

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Abstract

Introduction: Acute renal failure in intensive care often necessitates extracorporeal renal replacement therapy. Intermittent hemodialysis (IHD) and continuous veno-venous hemofiltration (CVVH) are the two primary techniques employed, yet their relative efficacy and tolerability remain subjects of debate. This study compares these modalities in terms of hemodynamic stability, biological efficacy, and patient survival. **Patients and Methods:** This retrospective study, conducted in a multipurpose intensive care unit, included 51 adult patients who underwent either IHD or CVVH. Clinical, biological, and survival data were analyzed, and factors influencing outcomes were assessed using appropriate statistical methods. **Results:** CVVH, utilized in 69% of patients, demonstrated better biological stabilization, as indicated by significantly lower creatinine levels at discharge ($p = 0.026$). However, IHD was associated with a significantly higher survival rate (81% vs. 43%, $p = 0.024$). Patients receiving CVVH exhibited greater clinical severity. **Conclusion:** CVVH appears more suitable for hemodynamically unstable patients, whereas IHD, which is well tolerated, is associated with improved survival outcomes. The selection of renal replacement therapy should be individualized based on the patient's clinical profile. Further prospective studies are warranted to validate these findings.

Keywords

Intermittent Hemodialysis (IHD), Continuous Veno-Venous Hemofiltration (CVVH), Intensive Care, Hemodynamic Stability, Biological Efficacy

1. Introduction

Background and Rationale

Acute renal failure (ARF) is a frequent and serious condition encountered in intensive care units (ICUs), often requiring renal replacement therapy (RRT) for metabolic waste elimination, electrolyte balance restoration, and volume regulation [1]. Among the various RRT modalities, intermittent hemodialysis (IHD) and continuous veno-venous hemofiltration (CVVH) are the two most widely used techniques, each with distinct operational mechanisms and clinical applications [2].

IHD is a widely established technique that uses a dialyzer to remove toxins and excess fluids over relatively short sessions (typically 3 - 4 hours) performed multiple times per week. It operates on the principle of diffusion, where solutes move across a semi-permeable membrane driven by concentration gradients. However, the rapid fluid and solute shifts associated with IHD can lead to hemodynamic instability, hypotension, and electrolyte imbalances, particularly in critically ill patients [3].

In contrast, CVVH is a continuous therapy that provides slow and steady solute and fluid removal over 24 hours or longer. This technique relies on convection rather than diffusion, utilizing hydrostatic pressure to remove solutes through ultrafiltration. CVVH is generally preferred for hemodynamically unstable patients due to its gradual fluid removal and better hemodynamic tolerance. However, it requires specialized equipment, continuous anticoagulation, and extended monitoring, making it resource-intensive [3].

Despite their widespread use, the optimal choice between IHD and CVVH in ICU settings remains debated. Several studies have explored their comparative efficacy and tolerability, but conclusions have been inconsistent. For instance, Ronco *et al.* [4]. suggested that continuous therapies like CVVH might provide superior hemodynamic stability in critically ill patients, reducing the risk of intradialytic hypotension. On the other hand, Gaudry *et al.* [5]. and the AKIKI and IDEAL-ICU trials [6] found no significant survival benefit between IHD and CVVH, emphasizing the need for individualized treatment decisions based on patient-specific factors [5]. Moreover, meta-analyses by Schneider *et al.* [7]. and Zhao *et al.* [8]. indicated that while CVVH may reduce the need for early treatment interruptions due to instability, it does not necessarily improve long-term survival or renal recovery.

Given these discrepancies, further comparative evaluation is warranted to refine ICU management strategies and improve patient outcomes. This study aims to assess the clinical indications, hemodynamic tolerability, and impact on biological parameters and survival between IHD and CVVH in critically ill patients. A clearer understanding of these modalities could aid in optimizing renal replacement therapy decisions in intensive care settings.

2. Methods

2.1. Nature, Period and Scope of the Study

We conducted a retrospective, descriptive, and analytical study covering the period from July 1, 2023, to July 31, 2024, in the polyvalent intensive care unit of the Grand Hôpital de l'Est Francilien, Saint Faron site.

2.2. Inclusion and Non-Inclusion Criteria

Adult patients (≥18 years) admitted to the general ICU of the Grand Hôpital de l'Est Francilien, Saint Faron site, during the study period were included if they had undergone extra-renal purification therapy (intermittent hemodialysis or continuous veno-venous hemofiltration) for acute or chronic renal failure.

Patients were excluded if their medical records were incomplete or poorly documented, preventing a reliable assessment of treatment indications, treatment parameters, and patient outcomes. This selection ensured a homogeneous cohort of critically ill adults undergoing extra-renal replacement therapy with consistent and comprehensive documentation.

2.3. Management of Incomplete Documentation

Patients with incomplete or poorly documented medical records were non-included in the study to ensure the accuracy and reliability of the data. In cases where gaps in documentation were identified, efforts were made to recover missing information by reviewing supplementary medical records, consulting nursing or physician notes, and reaching out to relevant healthcare providers for clarification. If these efforts did not yield sufficient data to reliably assess treatment indications, parameters, or outcomes, the patient was non-included in the analysis to prevent potential bias. This approach ensured that only patients with complete and consistent documentation were included, supporting valid and robust conclusions.

2.4. Judging Criteria

- **Primary endpoint:** Significant hemodynamic variability during dialysis, including early termination of the session due to hemodynamic instability.
- **Secondary endpoints:** Mean creatinine level at discharge, the need for continued dialysis upon ICU discharge, and mortality rates associated with different dialysis techniques.

2.5. Statistical Analysis

Data were analyzed with R software (version 4.4.2), using rigorously selected statistical tests to compare groups of patients treated with intermittent hemodialysis (IHD) and continuous veno-venous hemofiltration (CVVH). For continuous variables, distributions were checked for normality before applying tests for comparison of means (Student's t-test for normal data, or Mann-Whitney test otherwise). Comparisons of proportions between groups were made using the chi-square test or Fisher's exact test, depending on sample size and distribution. Multivariate analysis was conducted to adjust results for potential confounding factors, including age, comorbidities (hypertension, heart failure, chronic renal failure), treatment modalities (pump rate, dialysis bath, type of anticoagulation), as well as relevant clinical variables (mechanical ventilation, lactate levels, mean arterial pressure). The coefficients of the multivariate models were interpreted to assess the relative impact of each variable on observed outcomes, including hemodynamic tolerance and clinical outcomes.

3. Results

3.1. Breakdown by Type of EER

CVVH accounted for 68.6% of the sample, while HDI represented 31.4% (**Figure 1**).

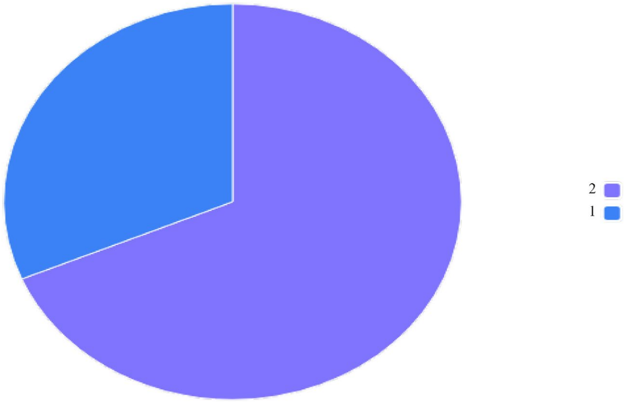


Figure 1. Population distribution by extra-renal purification type.

Figure 1 shows the population distribution by type of extra-renal purification: Type 1 = Intermittent hemodialysis (IHD) and Type 2 = Continuous veno-venous hemofiltration (CVVH).

3.2. Clinical Characteristics of the Population

Table 1. Clinical characteristics of the population.

		Type Dial 1 (N = 16)	Dial 2 Type (N = 35)	N	P	Test
Age		66.5 [57.0; 79.2]	67.0 [59.0; 72.5]	51	0.89	Mann-Whitney
Gender	M	10 (62%)	23 (66%)	33	0.82	Chi2
	F	6 (38%)	12 (34%)	18	-	-

Continued

DM	Yes	6 (38%)	13 (37%)	19	0.98	Chi2
	No	10 (62%)	22 (63%)	32	-	-
HTA	Yes	4 (25%)	10 (29%)	14	1	Fisher
	No	12 (75%)	25 (71%)	37	-	-
IC	Yes	11 (69%)	23 (66%)	34	0.83	Chi2
	No	4 (25%)	2 (5.7%)	6	-	-
CKD	Yes	12 (75%)	33 (94%)	45	0.069	Fisher
	No	4 (25%)	2 (5.7%)	6	-	-
BB	Yes	7 (44%)	17 (49%)	24	0.75	Chi2
	No	9 (56%)	18 (51%)	27	-	-

Legend: DM: Diabetes Mellitus; HTA: Hypertension; IC: ischemic cardiomyopathy; CKD: Chronic Kidney Disease; BB: Beta-blocker.

Table 1 shows the characteristics of the population according to extra-renal purification technique.

The clinical characteristics of the two groups (Dial Type 1 and Dial Type 2) are broadly similar, although the Dial Type 2 group has a higher proportion of chronic renal failure (94% vs. 75%) and slight differences in ischemic cardiomyopathy, hypertension and diabetes (Table 1).

3.3. Characteristics of the Intensive Care Unit Stay and Dialysis

IHD has a higher blood flow and more frequent use of LMWH heparin. CVVH, although stopped less frequently for hemodynamic instability (14%), is associated with exclusive use of norepinephrine, longer ICU stays and more frequent invasive ventilation, suggesting management of more severe patients. However, IHD has a superior survival rate despite a higher number of patients requiring dialysis after resuscitation (Table 2). The median SOFA score was 8 for patients who underwent IHD and 16 for those receiving CVVH.

Table 2. Characteristics of ICU stay and dialysis.

		Type Dial 1 (n = 16)	Dial 2 Type (n = 35)	N	P	Test
Dial delay		2.00 [0; 4.00]	4.00 [0; 9.00]	51	0.18	Mann-Whitney
Flow		275 [250; 300]	150 [110; 180]	51	<0.001	Mann-Whitney
Dial bath	225	1 (6.2%)	0 (0%)	1	<0.001	Fisher
	250	4 (25%)	3 (8.6%)	7	-	-
	350	2 (12%)	32 (91%)	34	-	-
	375	9 (56%)	0 (0%)	9	-	-

Continued

Anticoag	Hbpm	15 (94%)	3 (8.6%)	18	<0.001	Fisher
	Citrate	1 (6.2%)	31 (89%)	32	-	-
	No	0 (0%)	1 (2.9%)	1	-	-
Stop dial	Yes	0 (0%)	5 (14%)	5	0.17	Fisher
	No	16 (100%)	30 (86%)	46	-	-
Post-care EER	Yes	14 (88%)	23 (66%)	37	0.18	Fisher
	No	2 (12%)	12 (34%)	14	-	-
UF, n	Yes	12 (80%)	27 (77%)	39	1	Fisher
	No	3 (20%)	8 (23%)	11	-	-
LOS		7.00 [4.75; 12.0]	13.0 [7.00; 22.5]	51	0.066	Mann-Whitney
SOFA		8.00 [8.00; 12.0]	12.0 [8.00; 12.0]	51	0.26	Mann-Whitney
Ventilation	AA	8 (50%)	4 (11%)	12	0.014	Fisher
	NIV	2 (12%)	6 (17%)	8	-	-
	VI	6 (38%)	25 (71%)	31	-	-
Nad min		0 [0; 0]	1.00 [0; 4.75]	51	<0.001	Mann-Whitney
Nad max		0 [0; 0]	0.700 [0; 5.00]	51	<0.001	Mann-Whitney
Deaths	Yes	3 (19%)	20 (57%)	23	0.011	Chi2
	No	13 (81%)	15 (43%)	28	-	-

Dial delay = Time from ICU admission to the initiation of dialysis. **Flow** = Dialysis pump blood flow rate. **Dialysis Bath** = Composition of the dialysis solution: 225 = Potassium 2 mmol/L, Calcium 1.25 mmol/L; 250 = Potassium 2 mmol/L, Calcium 1.5 mmol/L; 350 = Potassium 3 mmol/L, Calcium 1.5 mmol/L; 375 = Potassium 3 mmol/L, Calcium 1.75 mmol/L. **Anticoagulation (Anticoag)** = Type of anticoagulation used. **Hbpm** = Low-molecular-weight heparin. **Citrate** = Citrate anticoagulation. **None** = No anticoagulation. **Dialysis stop** = Early termination of dialysis due to hemodynamic instability. **EER post-resuscitation** = Need for continued dialysis after resuscitation. **UF (Ultrafiltration)** = Use of ultrafiltration. **LOS (Length of Stay)** = Duration of ICU hospitalization. **SOFA**= SOFA Score. **Ventilation** = Type of ventilation used. **AA** = Ambient air. **NIV** = Non-invasive ventilation. **IV** = Invasive ventilation. **Nad min** = Minimum dose of noradrenaline used. **Nad max** = Maximum dose of noradrenaline used. **Death** = Mortality in the ICU.

3.4. Biological Parameters (Table 3)

Table 3. Compares biological results between two types of dialysis.

	Type Dial 1	Dial 2 Type	N	P	Test
	(n = 16)	(n = 35)			
Creat 1	673 [379; 886]	430 [315; 600]	51	0.14	Mann-Whitney
Creat 2	389 [268; 668]	245 [142; 364]	51	0.026	Mann-Whitney

Continued

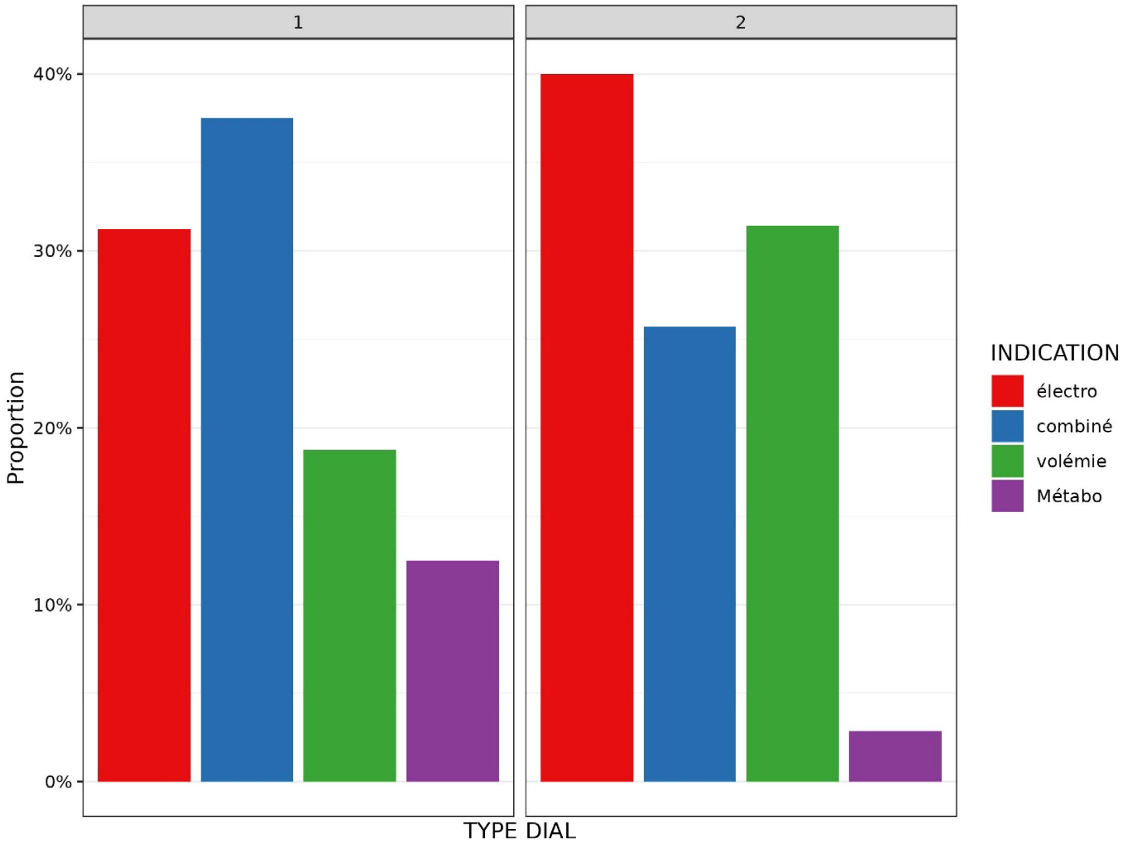
Uree 1	36.5 (20.9)	33.2 (13.8)	51	0.56	Welch
Uree 2	13.5 [6.57; 22.2]	9.90 [6.40; 15.5]	51	0.27	Mann-Whitney
Hb1	10.6 [9.17; 11.5]	9.60 [8.50; 10.7]	51	0.14	Mann-Whitney
Hb2	9.95 [9.28; 10.7]	9.35 [8.07; 10.5]	50	0.29	Mann-Whitney
Hco3 1	19.3 (5.95)	17.7 (6.48)	51	0.39	Welch
Hco3 2	21.6 (3.51)	22.9 (5.52)	51	0.29	Welch
K^+ 1	4.85 [4.25; 5.45]	4.80 [4.00; 5.90]	51	0.59	Mann-Whitney
K^+ 2	4.05 [3.58; 4.33]	4.10 [3.60; 4.55]	51	0.81	Mann-Whitney
Ca^{2+} 1	1.13 [1.02; 1.86]	1.23 [1.07; 1.95]	51	0.42	Mann-Whitney
Ca^{2+} 2	1.21 [1.04; 1.97]	1.80 [1.14; 2.00]	51	0.29	Mann-Whitney
Lact1	0.900 [0.700; 1.10]	1.50 [0.800; 5.85]	51	0.047	Mann-Whitney
Lact2	0.850 [0.675; 1.00]	1.20 [0.750; 2.05]	51	0.06	Mann-Whitney
Na^+ 1	137 [134; 138]	136 [132; 143]	51	0.85	Mann-Whitney
Na^+ 2	140 (4.64)	139 (3.77)	51	0.22	Welch
PCO2 1	37.0 [31.5; 39.2]	39.0 [31.1; 41.5]	51	0.4	Mann-Whitney
PCO2 2	32.9 [30.0; 37.0]	40.8 [35.0; 46.0]	51	0.014	Mann-Whitney

- Creatinine: Significant difference at discharge, lower for Type Dial 2 ($p = 0.026$).
- Urea, Hemoglobin, Bicarbonates, Potassium, Calcium, Sodium: No significant difference ($p > 0.05$).
- Lactates: Higher on admission for Dial Type 2 ($p = 0.047$), no difference on discharge ($p = 0.06$).
- PCO2: Higher at discharge for Type Dial 2 ($p = 0.014$).

3.5. Indications for Dialysis by Type

The main indications were electrolyte disorders, combined indications, hypervolemia and metabolic disorders. For CVVH, "Volemia" and "Electrolytic" problems were the most frequent, while for IHD, the "Combined" indication was the most common (Figure 2).

Figure 2 illustrates the main indications for extracorporeal purification according to the two modalities (HDI in purple and CVVH in blue). For HDI, the most common indications, in decreasing order, were combined indications (involving varying degrees of electrolyte imbalances, hypervolemia, and uremic syndrome), followed by electrolyte imbalances, hypervolemia, and metabolic disorders, primarily represented by uremic syndrome. For CVVH, the predominant indications, in decreasing order, were electrolyte imbalances, hypervolemia, combined indications, and metabolic disorders.



Legend: électro = Electrolyte disorders; Combiné = Combined indication; Volémie = Hypervolemia; Métabo = Metabolic disorder (uremic syndrome).

Figure 2. Breakdown of indications by type of dialysis.

3.6. Hemodynamic Tolerance of Intermittent Hemodialysis

MAP fluctuated at several stages during dialysis, showing significant changes (**Figure 3**). Multivariate analysis revealed that none of the variables had a statistically significant effect on hemodynamic tolerance ($p > 0.05$).

In **Figure 3**, the top chart illustrates the variations in mean arterial pressure (MAP) = PAM, and heart rate (HR) = FC, at different time points during Type 1 dialysis (Intermittent Hemodialysis). PAM is measured at several stages (PAM0 = baseline, PAM 1/2 = 30 min, PAM 1 = 1st hour, PAM 2 = 2nd hour, PAM3 = 3rd hour, PAM 4 = 4th hour), highlighting potential fluctuations in hemodynamic tolerance throughout the dialysis session. Similarly, heart rate values (FC0, FC1/2, FC1, FC2, FC3, FC4) depict changes in heart rate over time. On the lower chart, the lines illustrate significant PAM fluctuations during dialysis, with notable variations between different stages.

3.7. Relationship between Type of Dialysis and Mortality

The relationship between the type of dialysis (Intermittent Hemodialysis [IHD] vs. Continuous Veno-Venous Hemofiltration [CVVH]) and patient survival was analyzed, revealing significant differences in survival outcomes.

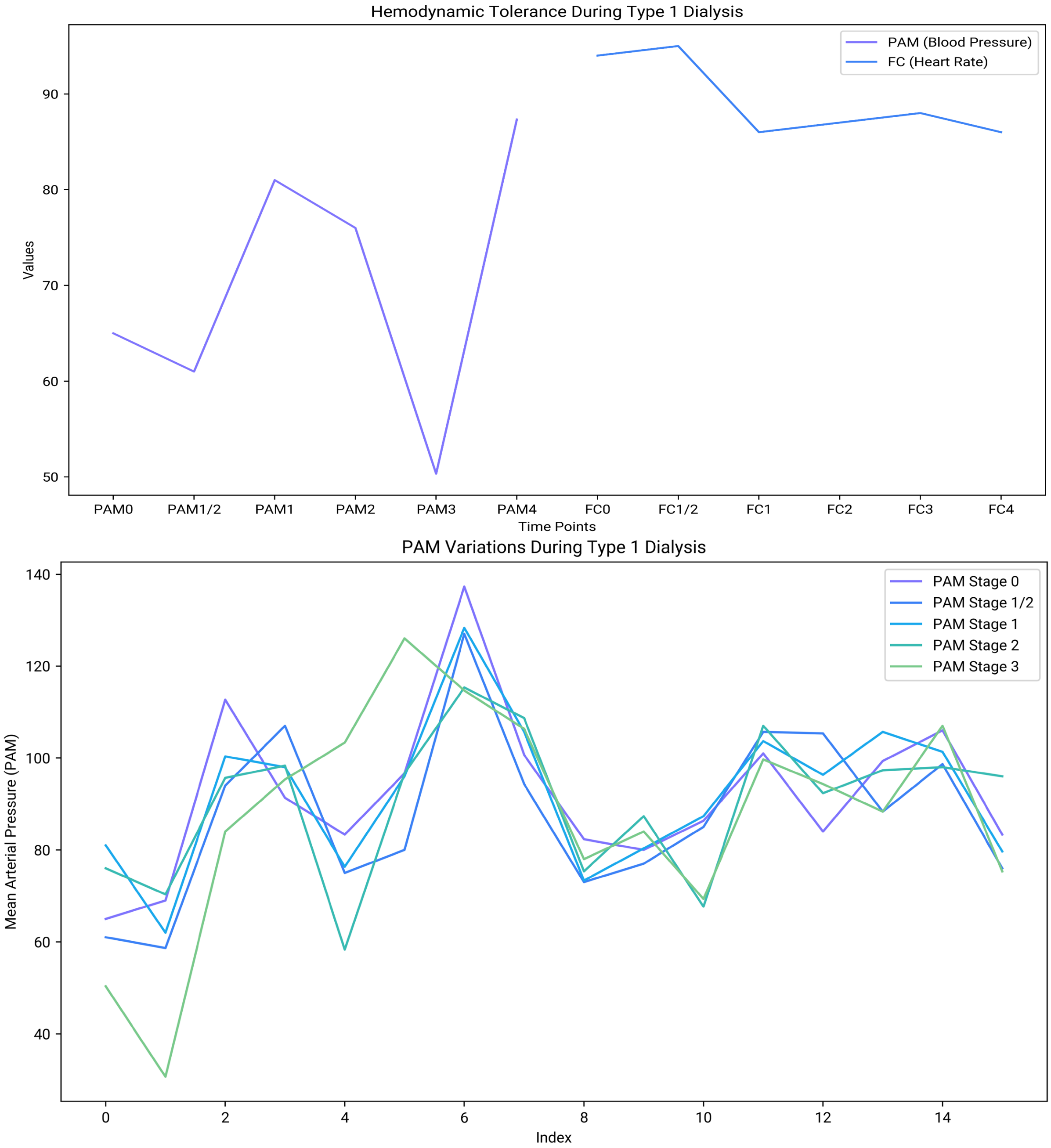


Figure 3. Hemodynamic tolerance of intermittent hemodialysis.

3.7.1. Survival Rates by Dialysis Type

- Intermittent Hemodialysis (IHD) (Type 1): The survival rate for patients undergoing IHD was 81.2%, reflecting a relatively high survival rate among this cohort. This could be partly attributed to the fact that IHD patients were generally younger and had fewer comorbidities compared to those on CVVH (**Figure 6**).

- Continuous Veno-Venous Hemofiltration (CVVH) (Type 2): The survival rate for patients on CVVH was 42.9%, which was significantly lower (p = 0.024) than that of the IHD group (**Figure 4**). This difference underscores the potential impact of dialysis modality on patient outcomes.

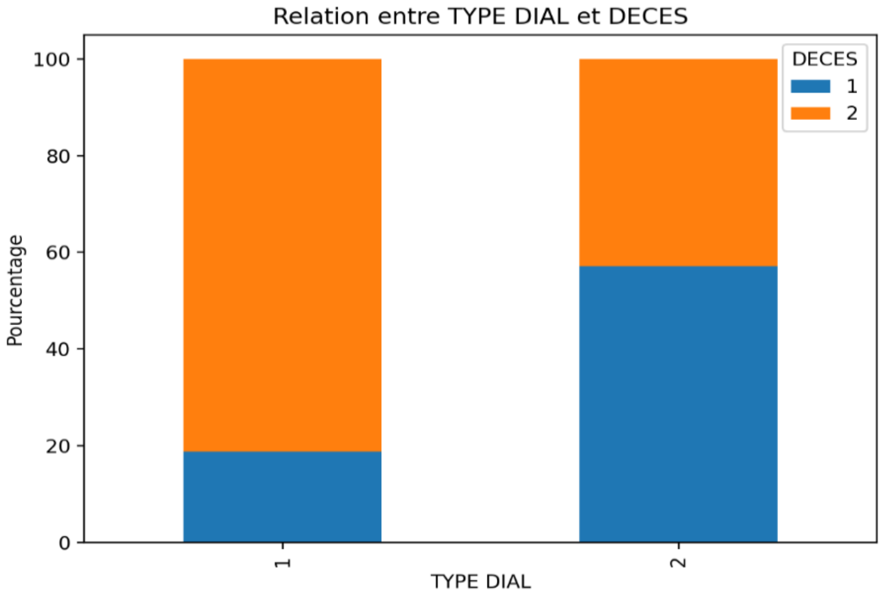


Figure 4. Relationship between type of dialysis and death.

Figure 4 illustrates survival outcomes based on the type of treatment. For hemodialysis (IHD, Type 1), 81.2% of patients survived (DECES = 2), while 18.8% did not (DECES = 1). In contrast, for continuous veno-venous hemofiltration (CVVH, Type 2), 42.9% of patients survived (DECES = 2), while 57.1% passed away. The analysis demonstrates that hemodialysis is associated with a significantly higher survival rate compared to continuous veno-venous hemofiltration, with a statistically significant difference (p = 0.024).

3.7.2. Factors Associated with Higher Mortality

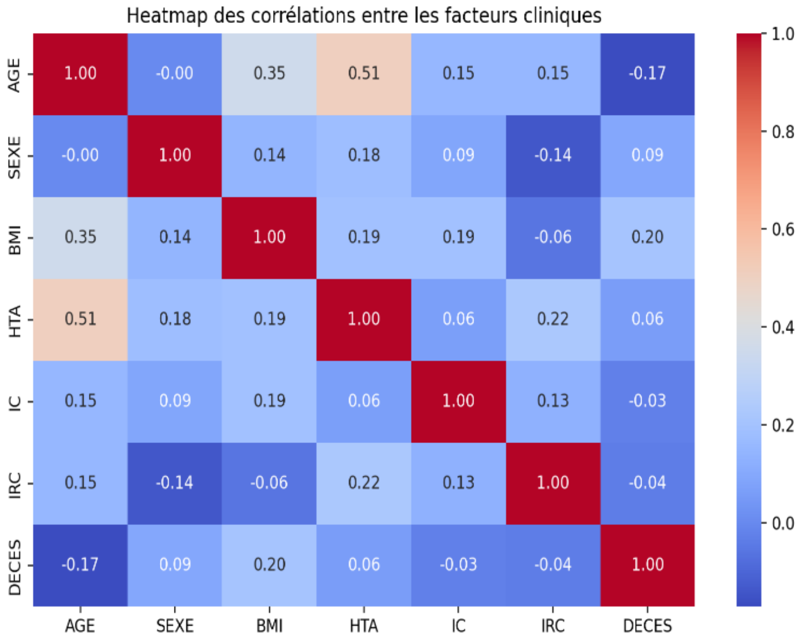


Figure 5. Correlation between clinical factors and death.

- Age: Older age was associated with higher mortality. The CVVH cohort, which had a higher proportion of elderly patients, showed poorer survival outcomes, likely due to age-related factors (**Figure 5**).
- Comorbidities: Hypertension, ischemic cardiomyopathy, and renal failure were identified as key factors contributing to higher mortality. Patients on CVVH had more comorbidities, which may have contributed to their lower survival rate (**Figure 5**).
- Body Mass Index (BMI): A higher BMI was also associated with increased mortality. Patients on CVVH had a higher BMI, which may have exacerbated other comorbid conditions, contributing to a higher risk of death (**Figure 6**).

3.7.3. Multivariate Analysis

The results from the multivariate analysis revealed interesting insights into the relative risks of different treatment modalities. While IHD was associated with an increased risk of death compared to CVVH (Odds ratio [OR] = [1.606769482]), CVVH appeared to offer significant protection, reducing the risk of mortality (OR = [0.622366812]).

High BMI and hypertension were identified as the most influential risk factors for mortality in this cohort. These factors remained significant even after adjusting for other variables (**Table 4**), highlighting the importance of managing weight and blood pressure in critically ill patients undergoing renal replacement therapy.

SOFA_BINARY: The coefficient is −1.68 with an odds ratio of 0.19, indicating that higher SOFA scores are associated with a lower probability of death.

Table 4. Multivariate analysis of factors influencing mortality.

Variable	Coefficient	Odds Ratio
BMI	0.654152324	1.923511311
TYPE DIAL_1	0.47422563	1.606769482
HTA	0.340798449	1.406069817
IC	−0.067873624	0.934378549
IRC	−0.286682288	0.750750213
TYPE DIAL_2	−0.47422563	0.622366812
AGE	−0.741776844	0.476266911
SOFA_BINARY	−1.6789884942	0.1865625897

3.7.4. Demographic and Clinical Differences

CVVH patients were generally older, had higher BMI, and presented with more comorbidities compared to those on IHD. These factors likely contributed to the observed differences in survival outcomes. On the other hand, IHD patients were younger and had fewer comorbidities, which may explain their higher survival rate (**Figure 6**).

The presence of age-related decline and comorbid conditions such as hypertension and heart failure is known to worsen prognosis, which was evident in this cohort.

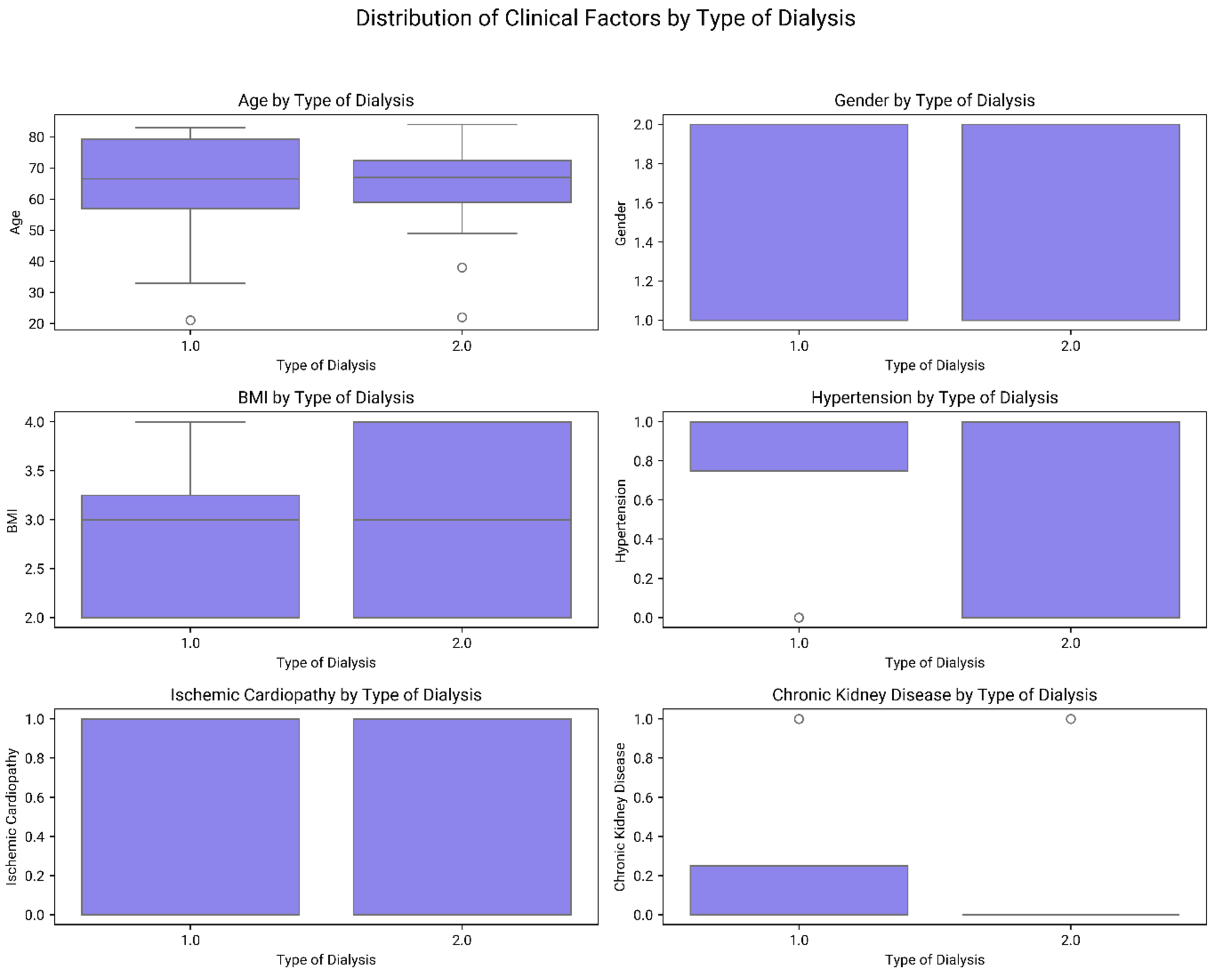


Figure 6. Distribution of clinical factors according to dialysis type.

Figure 6 illustrates the distribution of clinical factors based on the type of dialysis. It shows that Type 1 (IHD) appears to be more commonly used in younger patients, with greater variability in BMI and a higher proportion of hypertensive individuals. Type 2 (CVVH) shows a more homogeneous distribution in terms of age and BMI, with a slightly lower prevalence of hypertension and possibly fewer cases of chronic kidney disease. No major differences are observed in ischemic cardiomyopathy or gender distribution

3.8. Relationship between Type of Dialysis and Creatinine at Discharge

Analysis shows that creatinine at discharge is significantly lower for CVVH (Type 2, 292.43) compared with IHD (Type 1, 459.0), suggesting that CVVH may be more effective at reducing creatinine, although sample size and patient severity must be considered (**Figure 7**).

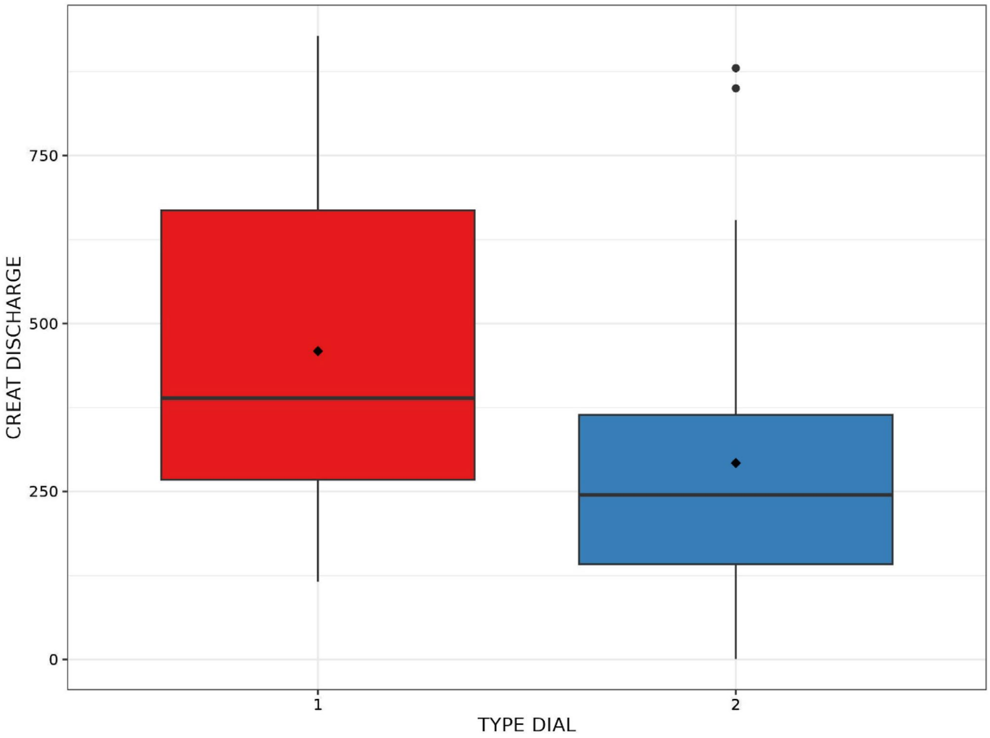


Figure 7. Relationship between type of dialysis and creatinine at discharge.

In **Figure 7**, the bar chart clearly illustrates a difference between the two types of dialysis, with higher average creatinine levels in conventional hemodialysis (Type 1) compared to CVVHD (Type 2). For IHD (Type 1), the mean creatinine level at discharge is 459.0 with a standard deviation of 260.11, based on a sample of 16 patients. For CVVHD (Type 2), the mean creatinine level is 292.43 with a standard deviation of 206.90, based on a sample of 35 patients.

4. Discussion

This single-center study compared the hemodynamic tolerance and efficacy of two extra-renal replacement therapy (ERT) techniques in the intensive care unit: continuous veno-venous hemofiltration (CVVH) and intermittent hemodialysis (IHD). CVVH was found to be the predominant modality, and it is used in around 69% of patients (**Figure 1**). Although there is no consensus on the choice of renal replacement technique in the ICU, both options are prescribed to varying degrees. A 2010 survey of resuscitators by the European Society of Intensive Care Medicine found that 92.6% were responsible for prescribing RRT. Of these, half reported using both intermittent hemodialysis and continuous renal replacement therapy techniques, although the majority favored CVVH [9]. Conversely, a French prospective observational multicenter cohort study, which included 1360 patients, showed that 40% of patients were initially treated with CVVH and 60% with IHD [10]. Other studies, mainly based on a randomized controlled trial design with proportional inclusions for each group, do not necessarily reflect resuscitators' spontaneous choice between these two techniques.

The patients' clinical data were comparable, irrespective of the EER technique used. They were elderly (mean age 67) and had comorbidities such as hypertension, diabetes, chronic renal failure and ischemic cardiomyopathy (**Table 1**). This profile is like that of patients admitted to intensive care requiring EER, as described in the literature [11] [12].

The main indications for EER, in order of frequency, were electrolyte disorders, intricate indications, hypervolaemia and metabolic disorders (**Figure 2**). These results are in line with those reported in the literature, where the most frequently observed indications include anuria, acute lung oedema, metabolic acidosis, hyperkalaemia and uraemic syndrome [13] [14].

The primary endpoint of this study was hemodynamic tolerance, particularly regarding intermittent hemodialysis (IHD). Variations in mean arterial pressure (MAP) and heart rate (HR) were analyzed during IHD sessions (**Figure 3**). It was observed that patients undergoing IHD showed significant fluctuations in MAP and HR, possibly indicating hemodynamic instability. No other variable, apart from the technique used, was associated with these fluctuations in multivariate analysis. However, there was no early interruption of sessions for hemodynamic instability in patients undergoing IHD, in contrast to patients undergoing CVVH, among whom 14% had to interrupt their sessions for hemodynamic instability. CVVH is generally preferred in hemodynamically unstable patients, as it may be associated with better hemodynamic tolerance [15]-[18]. However, a systematic review of randomized clinical trials comparing hemodynamic parameters between CVVH, IHD and hybrid therapy in patients with acute renal failure revealed no significant differences between the groups [19].

With regard to the efficacy of the two techniques, notably in terms of recovery of renal function, measured by creatinine at discharge from intensive care, and the need to continue dialysis after resuscitation, the study showed a significantly lower discharge creatinine in the CVVH group (245 vs. 389 µmol/l, $p = 0.026$) (**Figure 7**) and a higher proportion of patients requiring continued dialysis after resuscitation in the HDI group (88% vs. 66%) (**Table 3**). Although this difference was not statistically significant, these results suggest a potentially superior efficacy of CVVH, especially as the proportion of patients with chronic renal failure was higher (94%) in the CVVH group (**Table 1**). These findings are also corroborated by other studies in the literature, including an analysis of 16 French observational studies, which suggested a higher rate of dialysis dependence in survivors who initially received IHD compared with those treated with CVVH (RR 1.99 [95% CI 1.53 - 2.59], I2 = 42%) [7]. However, this trend was not confirmed by the 7 randomized trials included in the same analysis, which showed no significant differences between the two modalities [7].

In terms of survival, assessed by death rate, the analysis revealed that hemodialysis was associated with a higher survival rate than CVVH, with a statistically significant difference ($p = 0.024$) (**Figure 4**). Clinical factors associated with death included older age, with a mean of 67.5 years in deceased patients versus 62.5 years in survivors. In addition, arterial hypertension was present in 69.5% of deaths, heart failure in 34.7%, and renal failure in a notable proportion of cases (**Figure 5** and **Figure 6**). However, in multivariate analysis, only the treatment modality significantly influenced the mortality rate. These observations are also reported in the literature, notably in a meta-analysis of the effects of different EER modalities on recovery of renal function and survival in patients with acute renal failure. This analysis revealed higher ICU mortality in patients who received CVVH compared with those who received IHD [8]. Although not methodologically comparable, a secondary analysis of two randomized trials also showed that the 60-day Kaplan-Meier-weighted mortality rate was 54.4% in the CVVH group versus 46.5% in the IHD group (weighted HR 1.26, 95% CI 1.01 - 1.60) [5]. Another meta-analysis including five French studies, involving 1045 patients treated with CVVH and 1416 with HDI, showed no significant difference in mortality risk between the two modalities (HR = 1.10 [95% CI 0.95 - 1.27], p = 0.21), with moderate heterogeneity (I2 = 63%, p = 0.03) [20]. However, in our study, CVVH was associated with exclusive use of noradrenaline, longer ICU stays and more frequent invasive ventilation. This suggests that this modality is used to manage more severe patients. These results testify to the variability observed in terms of efficacy and survival between the two modalities, probably due to patient-specific indications and the severity of their clinical condition.

In contrast to established knowledge, our study found that a high SOFA score was associated with a reduced risk of mortality. This paradoxical finding may be explained by the fact that patients with higher SOFA scores were the most critically ill and predominantly received CVVH, which emerged in our study as a protective factor against mortality. This suggests that CVVH may act as a mortality-protective factor, independent of patient severity. Consequently, the improved survival observed in patients with higher SOFA scores might not reflect a lower intrinsic mortality risk but rather the potential benefits conferred by CVVH in managing critically ill patients.

This hypothesis is supported by findings from a study published in *Membranes*, which examined the impact of ultrafiltration rates during CVVH in patients with severe sepsis. The study demonstrated that, among patients with a SOFA score ≥15, a higher ultrafiltration rate was significantly associated with improved 90-day survival compared to standard ultrafiltration rates. These results suggest that specific CVVH modalities may offer survival benefits even in the most severely ill patients, potentially explaining the observed association between high SOFA scores and reduced mortality in our study [21].

Limitations of the Study

1) The retrospective nature of the study limits causal conclusions.

2) The small sample size (n = 51) reduces statistical power.

3) The selection bias associated with the choice of initial technique has not been fully elucidated.

5. Conclusion

This study shows that CVVH, thanks to its better biological stabilization, is suitable for hemodynamically unstable patients, while IHD, effective in stable patients, is associated with a better survival rate. The choice of technique must be individualized according to clinical profile. These results need to be confirmed by prospective studies to guide ICU strategies.

Ethics and Consent to Participation

The study was conducted in accordance with ethical standards, with informed consent obtained from all participants or their legal representatives.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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