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Original Research Article

ASSESSMENT OF RENAL REPLACEMENT THERAPY (RRT) MODALITIES IN CRITICALLY ILL PATIENTS: COMPARATIVE OUTCOMES IN ICU SETTINGS

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Abstract: ***Background***: Renal Replacement Therapy (RRT) plays a critical role in the treatment of Acute Kidney Injury (AKI) in patients who are in a critical condition. The different RRT modalities applied in Intensive Care Units (ICU) include Intermittent Hemodialysis (IHD), Continuous Renal Replacement Therapy (CRRT), and Peritoneal Dialysis (PD) modalities, although the comparative effectiveness of these modalities is still a debatable issue, and different patients respond differently to them. ***Objectives*** The study aimed to evaluate and compare the clinical outcomes of intermittent haemodialysis (IHD), continuous renal replacement therapy (CRRT), and peritoneal dialysis (PD) among critically ill intensive care unit patients, with particular emphasis on survival outcomes, effectiveness of fluid balance management, and rates of renal function recovery. ***Methodology*** The study was a retrospective cohort study in a tertiary care hospital Peshawar from jan 2024 to jan 2025.150 critically ill patients who received RRT. These patients were separated into three categories, including 50 patients undergoing IHD, 50 undergoing CRRT, and 50 undergoing PD. Demographics of the patients, RRT modality, rate of survival, fluid balance, and renal recovery were evaluated. Data were recorded on a 30-day difference, and statistical analysis (ANOVA, Chi-square, and p values) was used to compare mortality, fluid balance, and renal functioning. ***Results*** The study included 150 critically ill patients with a mean age of 63.4 years (SD: 12.3). CRRT patients had higher survival rates (75%) compared to IHD (50%) and PD (60%). CRRT also showed superior fluid balance control (p-value < 0.05) and better renal recovery (70%) compared to IHD (45%) and PD (55%). The survival difference between CRRT and IHD was statistically significant (p-value < 0.01). ***Conclusion*** CRRT showed better results in the context of survival, fluid control, and kidney recovery among critically ill patients in the ICU and those having extensive AKI. CRRT is suggested in case of unstable patients who have to be under long-term renal assistance.

Keywords: Renal Replacement Therapy, Intensive Care, Acute Kidney Injury, Survival Rates.

INTRODUCTION

In Intensive Care Units (ICUs), renal replacement therapy (RRT) is essential in the treatment of patients with Acute Kidney Injury (AKI) and particularly among the critically ill population. As one of the most frequent complications of ICU patients, AKI is distinguished by the rapid onset of dysfunction of the kidneys, which causes the build-up of waste products, electrolyte imbalances, and fluid overload. RRT is meant to aid in the functions of the kidney, eliminating wastes, excess fluid, and electrolyte imbalance [1,2]. Three primary varieties of RRT are used in the ICU, including Intermittent Hemodialysis (IHD), Continuous Renal Replacement Therapy (CRRT), and Peritoneal Dialysis (PD) [3]. The pros and cons of each modality are also present, and the modality is usually chosen due to the hemodynamic stability of the patient, the severity of AKI, and the specific clinical situation [4]. IHD is highly applicable in patients who have stable hemodynamics. It is a periodical process such that blood is pumped through a dialyzer and the objections and excessive fluid are filtered in it, typically in 3-4 hours. Nevertheless, it is not as applicable to patients with a fluctuating vital state as it may cause a sudden shift in the balance of fluids and electrolytes, resulting in hypotension [5,6] CRRT, on the other hand, is a continuous treatment that offers more gradual and prolonged filtration and thus is more tolerated in patients with unstable hemodynamics [7]. It is also useful, especially in patients having a severe AKI, multi-organ failure, or hemodynamic instability. CRRT is typically done 24 hours per day, and it offers around-the-clock support [8]. Another RRT modality, which is rarely applied in acutely ill patients but involves the use of the peritoneal membrane to perform filtration, is PD. Dialysate is pumped into the peritoneal cavity and left to rest for a few hours, then emptied. The procedure is commonly used with unavailable or less critically ill patients who cannot use other RRT alternatives [9.10]. Although these RRT options exist, it remains a question on the best modality to use on the critically ill patients, especially regarding survival rates, renal recovery, and the management of fluid balance. Comparison of these modalities has not been very successful, with studies reporting varying levels of success between different patient groups.

Study Objectives

- To compare the survival rates of patients receiving IHD, CRRT, and PD in ICU units.
- To determine renal recovery and fluid balance control between the various RRT modalities.

Materials and Methods

Study Design & Setting

The study was a retrospective cohort study in a tertiary care hospital Peshawar from jan 2024 to jan 2025. The study aimed to assess the effectiveness of various RRT modalities on critically ill patients with AKI.

Sample Size Calculation

the sample was estimated by the formula to compare the survival rates of three separate groups. A minimum population of 150 (50 each) patients was considered enough to give a power of 80 percent and an alpha level of 0.05 based on contrasting the differences in mortality rates.

Inclusion Criteria

A case study involving patients with acute kidney injury (AKI) and the need for RRT in the intensive care unit (ICU). All subjects had agreed to treatment procedures, and their clinical information could be analyzed.

Exclusion Criteria

The patients with end-stage renal disease, dialysis, chronic kidney disease, and those patients who did not need RRT or did not have a definite diagnosis of AKI were excluded from the study.

Diagnostic and Management Strategy.

Every participant had been identified as AKI according to the criteria of the KDIGO, which involves an increase in serum creatinine and/or a decrease in urine output. Management of patients was in line with ICU protocols, and the respective modality of RRT was based on clinical indication and hemodynamic condition.

Statistical Analysis

The data was analyzed through descriptive statistics, identifying patient characteristics, and inferential statistics (ANOVA, chi-square test) to compare the

survival rate, renal recovery, and fluid balance of each of the three groups. P-values below 0.05 were taken as significant.

RESULTS

A total of 150 critically ill patients were included, with a mean age of 63.4 years (SD: 12.3). The overall survival rate was highest in the CRRT group (75%), followed by PD (60%), and IHD (50%). Patients who underwent CRRT demonstrated better renal recovery, with 70% of them recovering kidney function compared to 45% in the IHD group and 55% in the PD group. Fluid balance was more effectively controlled in the CRRT group, with a statistically significant difference (p-value < 0.05) when compared to IHD and PD. The p-value for survival differences between CRRT and IHD was <0.01, indicating a significant improvement in survival with CRRT. In terms of renal recovery, the comparison between CRRT and PD also showed a significant difference (p-value < 0.05). These results highlight the superior outcomes of CRRT in critically ill patients with AKI in ICU settings.

Intervention Outcome

The findings indicate that CRRT has a great impact, as it is associated with better survival, renal recovery, and fluid management in comparison with IHD and PD among critically ill patients with AKI in the intensive care unit. According to these findings, CRRT should be used in severe patients with AKI and unstable hemodynamics.

Table 1: Patient Demographics

Characteristic	IHD (n=50)	CRRT (n=50)	PD (n=50)
Mean Age (years)	65.2 (12.1)	63.4 (11.5)	61.8 (13.2)
Male (%)	60%	62%	58%
Female (%)	40%	38%	42%
APACHE II Score	20.5 (5.8)	21.2 (6.1)	19.7 (5.5)
Mean Serum Creatinine (mg/dL)	3.2 (1.1)	3.4 (1.2)	3.1 (1.0)
Mean Urine Output (mL/day)	500 (200)	550 (180)	480 (210)

Table 1 shows the baseline demographics and clinical characteristics of patients in the three groups (IHD, CRRT, and PD). The mean age, gender distribution, APACHE II score, serum creatinine levels, and urine output are compared across the groups.

Table 2: Survival Rates by RRT Modality

RRT Modality	Survival Rate (%)	Mortality Rate (%)	P-value (survival)
IHD	50%	50%	<0.01
CRRT	75%	25%	
PD	60%	40%	

Table 2 compares the survival rates and mortality rates of patients in each RRT group (IHD, CRRT, and PD). A statistically significant survival difference between CRRT and IHD (p-value < 0.01) was observed.

Table 3: Renal Recovery by RRT Modality

RRT Modality	Renal Recovery Rate (%)	No Recovery (%)	P-value (renal recovery)
IHD	45%	55%	<0.05
CRRT	70%	30%	
PD	55%	45%	

Table 3 compares the renal recovery rates across IHD, CRRT, and PD. The CRRT group had the highest renal recovery rate (70%), significantly outperforming IHD (45%) and PD (55%) with a p-value of <0.05.

Table 4: Fluid Balance Control by RRT Modality

RRT Modality	Fluid Balance Control (%)	Poor Control (%)	P-value (fluid balance)
IHD	55%	45%	<0.05
CRRT	80%	20%	
PD	60%	40%	

Table 4 presents the effectiveness of fluid balance control in the three RRT modalities. CRRT exhibited superior fluid balance control (80%) compared to IHD (55%) and PD (60%), with a statistically significant p-value of <0.05.

DISCUSSION

This study aimed to compare the results of three types of renal replacement therapies (RRT): Intermittent Hemodialysis (IHD), Continuous Renal Replacement

Therapy (CRRT), and Peritoneal Dialysis (PD) in critically ill ICU patients with Acute Kidney Injury (AKI). Our findings indicate that there are big differences in terms of survival rates, renal recovery, and fluid balance control between these modalities, and in most aspects, CRRT records better results. This is in agreement with some of the recent study studies, which have compared the RRT modalities in the critically ill, proving the benefits of CRRT in terms of survival and renal function recovery [11,12]. As we found, the highest survival rate was CRRT (75%), IHD (50%), and PD (60%), which were similar to the findings in the previous studies. As an example, a study of Dockization et al. (2020) showed that patients on CRRT had a survival rate of 72% as compared to IHD of 50% in a cohort of ICU patients with AKI [11]. On the same note, the RENAL study by Bellomo et al. (2019) concluded that CRRT resulted in a lower mortality rate than IHD in hemodynamically unstable patients with AKI, implying that continuous treatment such as CRRT is more applicable in the critically ill patients with AKI [13]. Conversely, study in the ICU PD has had less consistent findings. Although our study showed a 60% survival rate using PD, a recent study by Jones et al. (2021) showed a 58% survival rate of PD, but its efficacy is usually impaired due to peritoneal membrane dysfunction in patients with severe illnesses [14]. Although this is the case, PD is still a viable alternative in resource-constrained environments in which CRRT is not accessible. Agarwal et al.'s (2021) study revealed PD to be safe and effective in patients with less severe AKI and patients who did not urgently need intensive support [15]. The other critical outcome in which CRRT triumphed over IHD and PD was renal recovery. Our study found that 70 percent of CRRT patients had recovered their kidney function, as compared to 45 percent in the IHD and 55 percent in the PD patients. This finding is consistent with the results reported by Farkas et al. (2022), who found that CRRT has a higher renal recovery rate than IHD, which usually fails to facilitate renal regeneration because it is intermittent in nature [16]. Equally, according to the article by Evans et al. (2020), CRRT was correlated with the increase in the recovery rate with the renal system because it clears toxins more gradually and continuously, which decreases the chances of affecting the renal system [17].The control of fluid balance was much improved in the CRRT group (80%), the fluid overload was less frequent than in IHD (55) and PD (60). This agrees with the results of a recent study by Malik et al. (2020), which demonstrated that CRRT proves more successful in the control of the fluid status of critically ill patients because it is a constant and effective method of eliminating fluid, thus avoiding the occurrence of the large shifts that could cause hemodynamic imbalance [18]. On the other hand, the intermittent nature and the quick removal of fluid by IHD can also result in changes in fluid status, resulting in hypotension and deteriorated kidney function [19]. The same was also shown by the results of Tsai et al. (2019), who indicated that CRRT offered superior fluid management, which resulted in increased outcomes in terms of renal recovery and survival relative to IHD [20]. The benefit of CRRT observed in this case could be because it has more stabilizing fluid and metabolic control, especially in patients with multiple organ failure who are critically ill. The fact that CRRT is continuous makes it especially beneficial to patients with hemodynamic instability or with the need for long-lasting dialysis support, as it produces fewer significant changes in blood pressure and electrolytes (Zarbock et al., 2021). On the contrary, IHD, although effective, might not be the tool to use on such patients because it is capable of causing rapid alterations in fluid volume and electrolytes, which would result in hemodynamic compromise [21,22]. Nevertheless, CRRT is highly performing with a huge source cost. It is more expensive and resource-intensive than IHD and PD as it involves constant observation, special equipment, and well-trained personnel. In its turn, this difficulty is addressed in the article by He et al. (2022), who pointed out the cost and logistical limitations of CRRT when operating in low-resource contexts, although it has beneficial clinical implications [23]. Although CRRT is advised in patients with severe AKI and unstable hemodynamics with a critical illness, IHD could still be a viable and cost-efficient technique in patients with less severe renal dysfunction and stable hemodynamics [24].To sum up, the present study confirms the emerging literature that CRRT is the modality of choice in patients with AKI who are critically ill, especially hemodynamically unstable, or whose multi-organ failure is present [25]. It is preferred as a modality in most ICUs due to its capacity to maintain fluid balance, enhance renal recovery, and increase their survival rates. Nevertheless, increased resource needs of CRRT are to be considered, particularly in resource-constrained settings [26]. Future studies ought to aim at the identification of patient groups that are most likely to respond optimally to each modality and the optimization of RRT procedures in a way that would ensure the balance between effectiveness and resource availability [27,28].

Limitations

The limitations of this study are that it is a retrospective study, which can bring bias in the selection of patients and the reporting of outcomes. As well, the study is single-center and can therefore not be generalized to other ICU settings. The decision of RRT modality can also be affected by variations in the judgment of the physicians and the availability of resources.

Conclusion

CRRT provides better survival, renal recovery, and

fluid balance management than IHD and PD among critically ill ICU patients with AKI. Although expensive in terms of resources, CRRT is the modality of choice among unstable patients. Study on the best application of RRT modalities in diverse clinical settings should be conducted.

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