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Hypertension Management in ICU: Exploring the Role of Blood Pressure Control in Renal Protection

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Abstract: ***Background:*** Hypertension is common in patients in the ICU, and most of the time, it results in such complications as acute kidney injury (AKI) and multi-organ dysfunction unless controlled. Blood pressure management is important in helping avoid kidney damage and improving overall patient outcomes. The paper examines the importance of blood pressure management in the renal protection of critically ill patients, focusing on its effects on their kidney function and prevention of AKI. ***Objectives:*** to evaluate the role of blood pressure management on renal functioning in the ICU patients, with special focus on the prevention of kidney injury and enhancement of kidney outcomes upon timely management of hypertension. ***Methodology:*** It is a prospective study involving 100 patients at department of nephrology prime teaching hospital Peshawar from june 2024 to june 2025. the ICU with ages ranging between 18 and 75 years, and all of them were diagnosed with hypertension. Patients with a pre-existing state of renal conditions were not allowed. The individualisation of blood pressure targets was pegged on the clinical status of every patient and followed over a period of 14 days. The appraisal of renal functioning was done through serum creatinine, urine output, and glomerular filtration rate (GFR). Paired t-tests and chi-square tests were performed to determine how blood pressure control and renal function are related. ***Results:*** The cohort had a mean age of 55.3 years (SD = 12.8). Blood pressure control was achieved in 85% of patients, with systolic blood pressure maintained between 140-160 mmHg. The mean baseline serum creatinine level decreased from 1.25 mg/dL to 1.10 mg/dL by the end of the study. Urine output increased by a median of 150 mL/day in patients with optimal blood pressure control. The incidence of AKI was significantly lower in patients with controlled blood pressure (15%) compared to those with suboptimal control (30%). The overall AKI incidence was 20%, showing that blood pressure management significantly reduces renal injury. ***Conclusion:*** Early and proper hypertension control is of the essence in patients in the ICU to minimise the occurrence of AKI and favour renal restoration. This paper focuses on the significance of customised blood pressure management, which

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helps to preserve the functioning of the kidneys and enhance patient outcomes in critically ill patients.

Keywords: Hypertension, ICU, renal protection, blood pressure control.

INTRODUCTION

High blood pressure is a common disease, with many critically ill patients in the intensive care unit (ICU) having this condition. Hypertension management in the ICU is one of the most crucial issues to be considered when working with a patient because uncontrolled hypertension may worsen the underlying condition and cause very serious complications, such as acute kidney injury (AKI), heart-related events, and neurological damage [1]. The renal system is especially susceptible to the negative outcomes of hypertension since chronic high blood pressure may result in reduced renal perfusion and glomerular damage, which in the end may cause AKI. Thus, blood pressure management is crucial to optimise and preserve the functioning of the kidneys and enhance the overall outcome of the ICU patients [2]. The recent study has made it clear that it would be imperative to have a target blood pressure that would limit the risk of renal injury to patients who are critically ill [3]. Although the optimal target can be different according to the clinical condition of the patient, there are indications that a systolic blood pressure (SBP) of 140-160mmHg can be optimal with most patients in the ICU [4]. The right management of blood pressure will contribute to reducing the risk of AKI, avoiding the further destruction of the kidney, and providing renal recovery [5]. Furthermore, the blood pressure management in the ICU is also advantageous since it lowers the cost of dialysis and other interventions that would be used in case of severe renal dysfunction. Hypertension in patients who are critically ill is commonly worsened by other underlying conditions, including sepsis, heart failure, or acute respiratory distress syndrome (ARDS) [6]. The state of these conditions may also make it difficult to control blood pressure and renal functioning. Moreover, the prescription of vasopressors, sedatives, and diuretics in the ICU may affect the mechanisms of blood pressure control and kidney perfusion, which should be closely monitored and regulated to change the treatment plan. Regulation of blood pressure has become a significant area of interest in the management of ICU patients, especially because renal failure has become a significant cause of morbidity and mortality in critically ill patients [7]. Kidneys are very sensitive to changes in blood pressure and need proper perfusion in order to work well. Persistent hypertension may disrupt renal autoregulation, decrease renal blood flow and raise glomerular filtration pressure, all of which may lead to renal injury and AKI [8]. The proposed study will attempt to examine the importance of blood pressure management in preserving the renal functions of ICU patients. In particular, it will explore the connection between blood pressure control and renal outcomes in terms of the rates of the development of AKI, alteration in renal biomarkers, including serum creatinine, and urine output rate in relation to blood pressure control [9]. Also, the analysis will determine the effectiveness of various antihypertensive measures, such as the use of vasodilators, beta-blockers, and diuretics in the achievement of optimal blood pressure control and the recovery of renal functions in patients in a critically ill condition. Because the management of hypertension among ICU patients is complex, it is important to realise the best mechanisms that could be used to prevent renal damage and ensure enhanced kidney performance. This study will hopefully add value to clinical practice by providing a better insight into the relationship between blood pressure control and renal protection that can be applied in clinical practice and lead to better patient outcomes in the ICU environment [10].

Study Objectives

In order to measure the efficacy of blood pressure management in preventing acute renal injury (AKI) and renal recovery in ICU patients, it is necessary to pay attention to the connection between blood pressure control and renal protection.

MATERIALS AND METHODS

Study Design & Setting

This was a prospective observational study that was carried out in at department of nephrology prime teaching hospital Peshawar from june 2024 to june 2025. It involved patients of the adult ICU with hypertension, and the subject of hypertension and its effect on renal performance.

Participants
The sample population comprised 100 adult patients between the ages of 18 and 75 years with hypertension and admitted to the ICU. Patients with underlying chronic renal disease, who are on dialysis, or who have a severe comorbidity (e.g. advanced cancer, end-stage liver disease) were excluded. Each of the patients who were included had to be provided with round-the-clock blood pressure checks and urine renal examination during their ICU stay.

Sample Size Calculation
The sample size was determined based on an alpha of 0.05 and a power of 80, and an estimated 20 per cent decrease in the incidence of acute kidney injury (AKI) was to be achieved with optimal blood pressure control. According to these parameters, the sample size was calculated to be 100 patients so that the statistical significance of the analysis of renal outcomes under the influence of blood pressure management could be achieved.

Inclusion criteria
Adult patients in the ICU diagnosed with hypertension between 18 and 75 years old, and those who require intensive care and management.

Exclusion criteria
Patients who have chronic kidney disease, are under dialysis, with severe comorbidities (e.g. advanced cancer, terminal illness), or who have contraindications to the interventions of blood pressure management.

Diagnostic and Management Strategy
Treatment of blood pressure was based on the patient's needs; the systolic blood pressure was set at 140-160 mmHg. Constant checks of the blood pressure and kidney activity (serum creatinine, urine output) were conducted. Pharmacologic therapy involved diuretics, vasodilators and beta-blockers.

Statistical Analysis
The data analysis was done using SPSS. Patient demographics and clinical variables were presented in descriptive statistics (mean, standard deviation). The results of paired t-tests and chi-square tests were used to compare the outcomes of renal functioning of patients with optimal and suboptimal blood pressure control. The p-value of less than 0.05 was regarded as important.

RESULTS

The study included 100 ICU patients with a mean age of 55.3 years (SD = 12.8). Blood pressure control was successfully achieved in 85% of the cohort, with systolic blood pressure maintained within the target range of 140-160 mmHg. Baseline serum creatinine levels averaged 1.25 mg/dL and decreased to 1.10 mg/dL by the end of the study. The median urine output in the cohort increased by 150 mL/day in patients with optimal blood pressure control, compared to a 50 mL/day increase in those with suboptimal control. The incidence of acute kidney injury (AKI) was significantly lower in the group with optimal blood pressure control (15%) compared to the group with suboptimal control (30%) ($p < 0.05$). The overall incidence of AKI in the study population was 20%. These findings suggest a strong association between blood pressure control and improved renal outcomes in ICU patients, with optimal blood pressure management reducing the risk of AKI and enhancing kidney recovery. The study further demonstrates that early and consistent blood pressure control is crucial for protecting renal function and improving ICU patient outcomes.

Intervention Outcome
The optimisation of blood pressure control demonstrated a significant decrease in the number of acute kidney injury (AKI) cases and renal work by lowering serum creatinine levels and increasing urine output. This underscores the usefulness of prompt management of blood pressure in avoiding destruction of the kidneys in ICU patients.

Table 1: Baseline Demographic and Clinical Characteristics of ICU Patients

Characteristic	Value (n = 100)
Mean Age (years)	55.3 (SD = 12.8)
Gender (Male/Female)	60/40
Mean SBP at Admission (mmHg)	160.4 (SD = 18.3)
Comorbidities (n, %)	Hypertension (85), Diabetes (40), Heart Failure (20)
Mean Serum Creatinine (mg/dL)	1.25 (SD = 0.3)
Mean Urine Output (mL/day)	850 (SD = 150)

This table presents the demographic and clinical characteristics of ICU patients at baseline. The mean age of participants was 55.3 years, with a slight male predominance (60%). Comorbidities like hypertension, diabetes, and heart failure were common. Baseline renal function was assessed using serum creatinine levels and urine output.

Table 2: Blood Pressure Control Achieved in ICU Patients

Blood Pressure Control	Optimal Control (n = 85)	Suboptimal Control (n = 15)
Mean SBP at Admission (mmHg)	160.4 (SD = 18.3)	162.5 (SD = 16.7)
Mean SBP at Discharge (mmHg)	150.2 (SD = 10.5)	170.8 (SD = 12.3)
Duration of BP Control (days)	14 (SD = 2)	10 (SD = 3)

This table compares the blood pressure control achieved in ICU patients, divided into two groups: optimal and suboptimal control. Optimal control was defined as maintaining systolic blood pressure (SBP) between 140-160 mmHg for the duration of the ICU stay. The duration of blood pressure control was significantly longer in patients with optimal control.

Table 3: Renal Function Outcomes in ICU Patients

Group	Serum Creatinine (mg/dL)	Urine Output (mL/day)	Incidence of AKI (%)
Baseline	1.25 (SD = 0.3)	850 (SD = 150)	20%
Optimal BP Control (n = 85)	1.10 (SD = 0.2)	1,000 (SD = 180)	15%
Suboptimal BP Control (n = 15)	1.30 (SD = 0.4)	750 (SD = 120)	30%

This table summarizes the renal function outcomes, including serum creatinine levels, urine output, and the incidence of acute kidney injury (AKI) in patients with optimal and suboptimal blood pressure control. Patients with optimal blood pressure control showed significantly better renal function and a lower incidence of AKI.

Table 4: Statistical Comparison of Renal Function Outcomes

Group	Serum Creatinine (p-value)	Urine Output (p-value)	AKI Incidence (p-value)
Optimal vs Suboptimal BP Control	0.02	0.03	0.01

This table shows the statistical comparison between the optimal and suboptimal blood pressure control groups for various renal outcomes. The p-values indicate significant differences in serum creatinine levels, urine output, and the incidence of AKI between the two groups, supporting the benefit of blood pressure control for renal protection.

DISCUSSION

Optimal renal outcomes, such as reduced acute kidney injury (AKI) rates, higher serum creatinine, and higher urine output, were found to be linked with optimal blood pressure (BP) control in comparison with suboptimal blood pressure (BP) control in this case study of 100 ICU hypertensive patients [11]. The findings correspond to and contribute to emerging evidence based on the value of BP control in renal protection in critically ill and the general hypertensive population, as reported by recent clinical studies [12]. Several guidelines and consensus statements have highlighted the intricacy of BP goals in patients with severe illness who more often have co-morbid conditions such as septic shock and chronic hypertension [13]. Indeed, individualised targets have been proposed by experts with the consideration of elevated mean arterial pressure (MAP) goals to maintain renal perfusion in patients with septic shock, with the incidence of AKI and renal replacement therapy being lower with higher MAP target goals (8085 mmHg) than with traditional target goals (6570 mmHg) [14]. This confirms our results in that renal failure can be averted in ICUs under the condition of keeping BP within a healthy range. This topic is also informed by recent large-scale study on hypertension not in the ICU [15]. Although carried out using a non-ICU population, some studies (e.g., the Systolic Blood Pressure Intervention Trial (SPRINT)) and secondary data (e.g., STEP) have tested intensive and standard BP targets and their impact on kidney outcomes [16]. Although intensive systolic BP targets (less than 120 mm Hg in SPRINT) were associated with increased risk of acute kidney disease, other studies, such as STEP, found no significant risk of increased kidney risk with moderately intensive targets [17]. Such conflicting results in ambulatory patients resonate with the necessity of a cautious strike of BP goals to provide the highest possible organ protection without causing hypoperfusion, which is particularly applicable to the population of hemodynamically unstable ICU patients. The time in target range (TTR) concept has recently become a focus of predicting the outcome of the kidneys [18]. An analysis of the European Heart Journal in 2025 revealed that the

longer the systolic BP was in the target range, the larger the risk of AKI reduction (adjusted HR 0.85 per 1 SD increase in TTR), which is why it is not only important to reach the targets but also to use them continuously [19]. This observation is consistent with our finding that patients with well-controlled BP showed improved renal parameters and reduced incidences of AKI. In contrast, the observational results based on the hospitalised patients receiving the treatment of severe hypertension indicate that intravenous antihypertensive treatment can be associated with an increased risk of AKI at the population level, which could be associated with the risks of excessively aggressive BP reduction or the destabilization of hemodynamics [20,21]. These observations support our arguments on the importance of customised BP goals and careful observation, which are important concepts in the ICU where the volume status and organ perfusion vary quickly [22]. Mechanistically, normal BP can be maintained to guarantee adequate renal perfusion pressure, which is necessary for glomerular filtration and ischemic injury prevention [23]. The management of AKI involves the use of supportive care mechanisms such as fluid optimisation and vasopressor selection, which also contribute to renal outcomes [24]. All these considerations indicate that BP control should not be considered in isolation, but rather it should interact with the overall hemodynamic optimisation in the Countably, and intensive BP control interventions in the management of chronic hypertension are still under development [25]. Studies advise against extrapolating these objectives to critically ill patients without taking into account their unique physiology [26]. However, the common thread in new literature, including consensus in the ICU and ambulatory hypertension trials and SBP TTR studies, is that more accurate and sustained BP management is associated with positive renal and cardiovascular outcomes, which are the fundamental conclusions of the present study [27].our findings are in line with the current evidence suggesting blood pressure management as an important adjustable variable in renal function preservation, especially among high-risk patients in the ICU. Through the comparison of these findings with the recent ones, we highlight a subtle and evidence-based practice on BP management in balancing perfusion to organs and maintaining hemodynamic stability to minimise the risk of AKI in critically ill individuals [28].

Limitations

This study has a number of limitations, such as it is based on an observational design that constrains the determination of causality. Although the sample size used is sufficient, it may not fully reflect all the populations of ICU patients. Also, personal differences in patient comorbidities and treatment plans could have affected the BP management and renal outcomes, which prevents its application in other environments.

CONCLUSION

The blood pressure management of the ICU patients has a considerable effect on lowering the risk of acute kidney injury and enhancing renal function. These results highlight the significance of personalised BP care in patients with severe illnesses to preserve kidney function and maximise outcomes, signifying the necessity of specific, ongoing blood pressure management interventions to be applied in intensive care units.

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