Original Article
DOI: https://doi.org/10.70749/ijbr.v3i5.1519

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

The Bidirectional Burden: Renal Dysfunction as a Prognostic Marker in Acute Stroke Patients at BMC Hospital Quetta

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ARTICLE INFO

Keywords: Renal dysfunction, Acute stroke, Prognostic marker, Bidirectional relationship, Stroke outcomes, Kidney function, Stroke prognosis, Renal impairment, Neurological outcomes.

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Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript.

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 26-02-2025 Revised: 07-05-2025
Accepted: 17-05-2025 Published: 31-05-2025

ABSTRACT

Background: Renal dysfunction is a prevalent comorbidity in acute stroke patients. This study aimed to evaluate the frequency, severity, and prognostic implications of renal impairment in individuals with acute ischemic and hemorrhagic strokes. **Methods:** This observational, hospital-based cohort study was performed at BMC Hospital Quetta from March 2024 to December 2024, enrolling 140 patients with acute stroke. Renal dysfunction was characterized by an eGFR of less than 60 mL/min/1.73m^2 or acute kidney injury (AKI) according to KDIGO criteria. Statistical analysis encompassed comparison testing, correlation, and multivariate logistic regression, while controlling for confounding variables. **Results:** Patients with renal failure (n=56, 40%) were substantially older (68.5±10.2 vs. 62.1±13.5 years; p=0.003) and exhibited elevated rates of hypertension (80.4 vs. 50.0; p=0.01) and diabetes (62.5 vs. 20.2; p=0.02). They demonstrated increased stroke severity (median NIHSS 15 against 10; p=0.001) and higher infarct sizes (32.4±20.1 versus 20.1±15.3 cm^3; p=0.004). Renal failure correlated with markedly elevated in-hospital mortality (32.1 vs. 4.8; p=0.001), 30-day mortality (44.6 vs. 10.7; p=0.002), heightened functional disability at discharge (98.2 vs. 37.7; p=0.005), and extended hospital stays (12 vs. 8 days; p=0.003). Multivariate analysis revealed renal dysfunction as an independent predictor of death (adjusted OR: 3.8, 95% CI: 1.9–7.6; p=0.001). **Conclusion:** Renal failure serves as a critical and independent prognostic indicator for unfavorable outcomes in acute stroke patients, associated with heightened stroke severity, elevated mortality, and increased disability. Timely recognition and customized therapy of renal impairment are essential to enhance outcomes in this at-risk population.

INTRODUCTION

Worldwide, stroke continues to be the leading cause of mortality and morbidity; it is responsible for almost 11% of all fatalities and 5% of disability-adjusted life years (DALYs) [1, 2]. Acute stroke, including ischemic and hemorrhagic types, is frequently accompanied by systemic comorbidities that aggravate cerebral damage and deteriorate clinical outcomes [3-5]. Renal dysfunction, which includes chronic kidney disease (CKD) and acute kidney injury (AKI), has become a significant prognostic factor in stroke patients; yet, its importance is often inadequately explored in many clinical contexts [6-9]. The relationship between renal impairment and stroke is bilateral. Chronic kidney disease, defined by a glomerular filtration rate (eGFR) <60 mL/min/1.73m^2, due to common pathophysiological mechanisms, such as endothelial dysfunction, chronic inflammation, and hypertension [10-13]. Conversely, acute stroke may induce renal impairment via mechanisms including hemodynamic instability, neurohormonal activation, and iatrogenic factors (contrast agents, nephrotoxic medications) [14-17]. There is new evidence that even minor renal dysfunction upon admission, as evidenced by lower eGFR, raised serum creatinine, or albuminuria, is associated with poor functional recovery, longer hospital stays, and increased mortality in stroke patients[18-20]. Nonetheless, renal function is frequently neglected in acute stroke care regimens, especially in resource-constrained areas. The burden of renal dysfunction is not well understood in Pakistan, despite the fact that the country's growing aging population, increasing rates of hypertension, diabetes, and cardiovascular diseases are all contributing to a rise in stroke incidence [21-23]. BMC Hospital Quetta, a tertiary care facility in Balochistan, caters to a community with restricted access to preventative healthcare, hence heightening the risk of misdiagnosed chronic kidney disease and postponed stroke interventions [24]. No research from this region have comprehensively assessed the prevalence, severity, or prognostic importance of renal impairment in patients with acute stroke. This is the first thorough analysis of renal impairment in acute stroke patients from

Balochistan, Pakistan. By combining clinical, biochemical, and imaging data, it emphasizes the necessity for regular renal function evaluation in stroke treatments. The results may inform targeted interventions, such as hydration regimens, blood pressure management, and the avoidance of nephrotoxic agents, to reduce kidney injury and enhance outcomes in at-risk patients.

Study Design and Setting Results

This was an observational cohort study conducted in the Department of Neurology, BMC Hospital Quetta, Pakistan. The study duration extended from March 2024 to December 2024. The primary objective of this study was to assess the prevalence, severity, and prognostic implications of renal impairment in patients hospitalized with acute stroke, including both ischemic and hemorrhagic variants. Ethical approval for the study was obtained from the Institutional Review Board of BMC Hospital.

Study Population

The study included adult patients admitted to BMC Hospital with an acute stroke. To qualify for inclusion, patients must be adults (aged ≥18 years) diagnosed with acute stroke, as verified by neuroimaging (Computed Tomography (CT) or Magnetic Resonance Imaging (MRI)) within 48 hours of symptom onset. Furthermore, the presence of baseline renal function assessments, serum creatinine, and estimated Glomerular Filtration Rate (eGFR), at the time of hospital admission was compulsory. Patients were excluded if they had End-Stage Renal Disease (ESRD) requiring dialysis before hospital admission, exhibited severe brain damage or subarachnoid hemorrhage, or possessed inadequate clinical or laboratory data that would hinder thorough analysis. Informed written consent was acquired from each participating patient or their legally designated representative.

Data Collection

Data were systematically gathered utilizing a defined proforma and medical records. Essential data encompassed demographic and clinical attributes (age, sex, BMI, medical history, time to admission), stroke features (type, NIHSS score, infarct/hematoma volume), and renal function. Renal function evaluation encompassed baseline serum creatinine and estimated glomerular filtration rate (eGFR) utilizing the CKD-EPI equation, acute kidney injury (AKI) criteria as defined by KDIGO (≥ 0.3 mg/dL increase within 48 hours or ≥ 1.5 times baseline within 7 days), and biomarkers including serum creatinine, eGFR, urine albumin-to-creatinine ratio (ACR), and cystatin C. The evaluated outcomes were short-term (in-hospital mortality, 30-day mortality, length of stay, and modified Rankin Scale at discharge) and long-term (6-month mortality via follow-up) metrics.

Operational Definitions

Data interpretation was made consistent and clear by using defined operational definitions. Renal impairment was characterized by an eGFR of less than 60 mL/min/1.73m^2 (equivalent to CKD stages 3–5) or the incidence of AKI during hospitalization. Stroke severity was classified according to NIHSS scores: mild (NIHSS score ≤5), moderate (NIHSS score 6–15), and severe (NIHSS score >15). Functional disability was characterized by a modified Rankin Scale (mRS) score of ≥3 at discharge, signifying moderate-to-severe disability.

Statistical Analysis

All data were analyzed using SPSS version 26 and R version 4.1.2. Descriptive statistics comprised mean ± SD or median (IQR) for continuous data, and frequencies (%) for categorical variables. Comparative analysis employed Student's t-test or Mann-Whitney U for continuous data, and Chi-square or Fisher's exact test for categorical data. Spearman's rank correlation (ρ) evaluated non-parametric relationships. Multivariate logistic regression identified predictors of mortality and adverse outcomes, controlling for age, NIHSS, hypertension, and diabetes. Cox proportional hazards regression was employed for time-to-event analyses. Kaplan-Meier curves and log-rank tests evaluated 30-day mortality. Cases with more than 20 missing variables were removed. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

140 acute stroke patients admitted to BMC Hospital Quetta were enrolled in this study. The cohort was divided into two groups: those with renal dysfunction (defined as an estimated glomerular filtration rate (eGFR) of less than 60 mL/min/1.73 m2 or acute kidney injury (AKI) based on KDIGO criteria) and those without.

Baseline Characteristics

The baseline characteristics of the study participants are summarized in Table 1. A significant age difference was observed between the two groups, with patients suffering from renal dysfunction being notably older (68.5±10.2 years) compared to those without renal dysfunction (62.1±13.5 years; p=0.003). Furthermore, the prevalence of comorbidities was significantly higher in the renal dysfunction group. Hypertension was present in 80.4% of patients with renal dysfunction versus 50.0 in the non-dysfunction group (p=0.01). Similarly, diabetes mellitus was diagnosed in 62.5% of patients with renal dysfunction compared to 20.2% in the control group (p=0.02). No statistically significant differences were found between the groups regarding sex distribution, Body Mass Index (BMI), or smoking status (p>0.05 for all).

Stroke Characteristics and Imaging Findings

Ischemic stroke was the predominant type, accounting for 75% of all cases. There was no significant difference in the distribution of stroke types between the renal dysfunction and non-dysfunction groups (p=0.18). However, stroke severity, as assessed by the National Institutes of Health Stroke Scale (NIHSS) scores, was considerably higher in patients with renal dysfunction. The median NIHSS score for the renal dysfunction group was 15 (Interquartile Range [IQR]: 10–20), whereas it was 10 (IQR: 6–14) for the non-dysfunction group (p=0.001). Patients with renal dysfunction also experienced longer delays in hospital admission, averaging 5.2±3.1 hours compared to 3.9±2.4 hours in the non-dysfunction group (p=0.02). Imaging results further indicated that patients with renal dysfunction exhibited significantly larger infarct volumes

(32.4±20.1 cm3) compared to those without renal dysfunction (20.1±15.3 cm3; p=0.004), as detailed in Table 2.

Renal Function Profiles

The renal dysfunction group demonstrated significantly elevated baseline creatinine levels (1.8±0.5 mg/dL) compared to the non-dysfunction group (0.9±0.2 mg/dL; p<0.001). Correspondingly, their eGFR was markedly reduced (45.2±15.4 mL/min/1.73m2) in contrast to the non-dysfunction group (85.3±18.6 mL/min/1.73m2; p<0.001). Acute kidney injury (AKI) was exclusively observed in the renal dysfunction group, with an incidence of 20 (p<0.001). Furthermore, urinary albumin-to-creatinine ratios (ACR) were substantially higher in patients with renal dysfunction, with a median of 300 mg/g (IQR: 150–600) compared to 50 mg/g (IQR: 20–100) in the non-dysfunction group (p<0.001). Table 3 provides insights into the renal function profiles of the cohort.

Prognostic Outcomes (Table 4)

In-hospital mortality was significantly higher in the renal dysfunction group, with a rate of 32.1 %compared to 4.8% in the non-dysfunction group (adjusted Odds Ratio [OR]: 4.2, 95 Confidence Interval [CI]: 1.8–10.1; p=0.001). By 30 days post-admission, mortality rates increased to 44.6% in the renal dysfunction group versus 10.7% in controls (adjusted OR: 3.6, 95 CI: 1.6–8.3; p=0.002). Functional disability, defined as a modified Rankin Scale (mRS) score of ≥3 at discharge, was more frequently observed in renal dysfunction patients (98.2 vs. 35.7; adjusted OR: 2.8, 95 CI: 1.4–5.6; p=0.005). Additionally, patients with renal dysfunction experienced longer hospital stays, with a median of 12 days (IQR: 9–16) compared to 8 days (IQR: 5–11) for the non-dysfunction group (p=0.003). The prognostic outcomes are outlined in Table 4.

Predictors of Mortality

Identified several independent predictors of mortality. Renal dysfunction emerged as a significant independent predictor (adjusted OR: 3.8, 95 CI: 1.9–7.6; p=0.001). Other significant predictors included an NIHSS score greater than 15 (OR: 4.2, 95 CI: 2.1–8.4; p<0.001) and age greater than 65 years (OR: 2.1, 95 CI: 1.1–4.0; p=0.03). Notably, diabetes mellitus did not independently predict mortality in this analysis (p=0.21), presented in Table 5,

Correlations and Survival Analysis

Beyond the tabular data, strong correlations were observed between renal dysfunction and key stroke indicators. Renal dysfunction correlated significantly with stroke severity (Spearman's ρ=0.42, p<0.001) and infarct volume (ρ=0.38, p=0.002). Furthermore, elevated urine ACR and baseline creatinine levels were inversely associated with eGFR (Spearman's ρ=−0.61 and ρ=−0.74, respectively; p<0.001 for both).

Kaplan-Meier survival curves (Figure 1, not shown) graphically illustrated the impact of renal dysfunction on patient survival. These curves demonstrated a significantly reduced 30-day survival rate in patients with renal dysfunction compared to those without (log-rank p<0.001).

Table 1

Demographic and Baseline Characteristics

Variable	Total Cohort (n=140)	Renal Dysfunction Group (n=56)	Non-Dysfunction Group (n=84)	p-value
Age (years)	65.2 ± 12.3	68.5 ± 10.2	62.1 ± 13.5	0.003
Sex (Male)	82 (58.6%)	30 (53.6%)	52 (61.9%)	0.25
BMI (kg/m^2)	26.4 ± 4.8	27.1 ± 5.1	25.8 ± 4.3	0.12
Hypertension	95 (67.9%)	45 (80.4%)	50 (59.5%)	0.01
Diabetes Mellitus	52 (37.1%)	35 (62.5%)	17 (20.2%)	0.02
Current Smokers	44 (31.4%)	20 (35.7%)	24 (28.6%)	0.45

Table 2

Stroke Characteristics and Severity

Variable	Total Cohort (n=140)	Renal Dysfunction Group (n=56)	Non-Dysfunction Group (n=84)	p-value
Stroke Type				0.18
- Ischemic	105 (75%)	40 (71.4%)	65 (77.4%)	
- Hemorrhagic	35 (25%)	16 (28.6%)	19 (22.6%)	
NIHSS Score	12 (8–18)	15 (10–20)	10 (6–14)	0.001
Time to Admission (hrs)	4.5 ± 2.8	5.2 ± 3.1	3.9 ± 2.4	0.02
Infarct Volume (cm^3)	25.6 ± 18.2	32.4 ± 20.1	20.1 ± 15.3	0.004

Table 3

Renal Function and Biomarkers

Variable	Total Cohort (n=140)	Renal Dysfunction Group (n=56)	Non-Dysfunction Group (n=84)	p-value
Baseline Creatinine (mg/dL)	1.2 ± 0.4	1.8 ± 0.5	0.9 ± 0.2	<0.001
eGFR (mL/min/1.73m^2)	68.5 ± 22.3	45.2 ± 15.4	85.3 ± 18.6	<0.001
AKI Incidence	28 (20%)	28 (50.0%)	0 (0%)	<0.001
Urine ACR (mg/g)	120 (30–450)	300 (150–600)	50 (20–100)	<0.001

Table 4

Outcomes and Prognosis

Variable	Total Cohort (n=140)	Renal Dysfunction Group (n=56)	Non-Dysfunction Group (n=84)	p-value	Adjusted OR/HR (95% CI)
In-Hospital Mortality	22 (15.7%)	18 (32.1%)	4 (4.8%)	0.001	OR: 4.2 (1.8–10.1)*
30-Day Mortality	34 (24.3%)	25 (44.6%)	9 (10.7%)	0.002	OR: 3.6 (1.6–8.3)*
mRS ≥3 at Discharge	85 (60.7%)	55 (98.2%)	30 (35.7%)	0.005	OR: 2.8 (1.4–5.6)*
Hospital Stay (days)	10 (7–14)	12 (9–16)	8 (5–11)	0.003	HR: 1.9 (1.2–3.0)**

Table 5
Multivariate Regression Analysis for Mortality

Predictor	Adjusted OR	95% CI	p-value
Renal Dysfunction	3.8	1.9–7.6	0.001
NIHSS >15	4.2	2.1–8.4	<0.001
Age >65	2.1	1.1–4.0	0.03
Diabetes Mellitus	1.5	0.8–2.9	0.21

DISCUSSION

This study examined the frequency, severity, and prognostic implications of renal impairment in a group of 140 acute stroke patients hospitalized in BMC Hospital Quetta, Pakistan. Our data highlight the major influence of renal dysfunction on stroke features and patient outcomes, demonstrating notable correlations with advanced age, elevated comorbidity burden, increased stroke severity, and diminished short-term prognosis.

Our findings indicate that patients with renal dysfunction were much older and exhibited a greater prevalence of hypertension and diabetes mellitus, aligning with established risk factors for both renal impairment and cerebrovascular disease [25-27]. This underscores the intricate interaction of cardiovascular risk factors that predispose patients to both renal illness and stroke. The elevated NIHSS scores and increased infarct volumes in the renal dysfunction cohort imply that impaired renal function may signify a more severe initial stroke presentation, possibly attributable to underlying systemic vascular pathology or diminished physiological responses to acute injury. Prolonged delays in hospital admission for these individuals may intensify stroke severity, however, the causal relationship requires further studies.

The comprehensive renal function assessments indicated that our renal failure cohort displayed markedly increased baseline creatinine levels, diminished eGFR, and raised urine ACR, alongside a sole incident of AKI. These findings underscore the significant divergence in renal function between the two groups and highlight the critical role of these markers in identifying patients at elevated risk. The significant inverse correlations between eGFR and both urine ACR and baseline creatinine are anticipated and confirm the validity of these indicators in evaluating renal health.

Our study demonstrated a markedly elevated in-hospital and 30-day mortality rate in individuals with renal impairment. This corresponds with an expanding corpus of literature suggesting that renal dysfunction independently predicts negative outcomes in acute stroke[28-31]. The heightened functional handicap at release and extended hospitalizations underscore the significant burden that co-existing renal dysfunction places on stroke recovery. Multivariate logistic regression separately identified renal dysfunction, NIHSS >15, and age >65 years as significant predictors of mortality, thereby supporting the independent prognostic significance of renal dysfunction beyond conventional stroke severity and age. Diabetes mellitus did not independently forecast death in our adjusted model, indicating that its effect may be primarily mediated by its association with renal impairment and total cardiovascular risk. The Kaplan-Meier analysis corroborated these findings, demonstrating a markedly decreased 30-day survival rate in the renal failure cohort.

However, this study also has limitations. As a single-center study, the applicability of our findings to other populations or healthcare environments may be constrained. The study's observational design prevents conclusive conclusions about causality. Although we accounted for several significant confounders in our regression models, residual confounding from unmeasured variables cannot be completely excluded. The evaluation of six-month mortality depended on follow-up calls and data, which may have resulted in some attrition, although measures were implemented to mitigate this issue. Moreover, the precise etiology of renal failure (pre-existing chronic kidney disease versus new acute kidney injury) was classified broadly, and a more detailed analysis could yield further insights.

CONCLUSION

The results of this study strongly suggest that renal impairment is a distinct and substantial predictor of unfavorable outcomes in patients referred to BMC Hospital Quetta with acute stroke. Our findings indicate that individuals with renal failure exhibit heightened stroke severity, larger infarct sizes, significantly elevated in-hospital and 30-day mortality rates, increased functional disability, and prolonged hospitalizations.

The significant correlation between renal impairment and adverse stroke outcomes underscores the urgent necessity for prompt detection and customized care approaches for this at-risk group. It is essential to do a routine evaluation of renal function upon admission. Our findings highlight the significance of holistic, interdisciplinary treatment to enhance neurological recovery and survival rates. Future multicenter interventional trials are necessary to investigate tailored nephroprotective treatments to enhance prognosis.

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