

PREVALENCE AND PROGNOSTIC SIGNIFICANCE OF KIDNEY DYSFUNCTION AMONG ACUTE STROKE PATIENTS IN A TERTIARY HOSPITAL**Nisha Gaur¹, Sumit Sukaldas Kamble²**¹Assistant Professor, Department of Nephrology, Jaipur National University Institute for Medical Sciences and Research Centre, Jaipur, Rajasthan, India²Associate Professor, Department of Neurology, National Institute of Medical Sciences and Research, NIMS University, Jaipur, Rajasthan, India

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Conflict of interest: Nil

Abstract:**Background:** Chronic kidney disease and stroke share many vascular risk factors, and markers of renal injury may carry prognostic information in the acute phase of stroke.**Aim:** To examine the relationship between kidney dysfunction at admission, stroke severity, and 30-day outcomes.**Materials and Methods:** This prospective cohort study enrolled 160 consecutive adults with CT-confirmed acute stroke at a tertiary hospital. Stroke severity was graded with the National Institutes of Health Stroke Scale (NIHSS). Kidney dysfunction was defined as albuminuria (urine albumin-creatinine ratio ≥ 30 mg/g) and/or an estimated glomerular filtration rate (eGFR) below 60 mL/min/1.73 m². Patients were followed for 30 days for death and functional status on the modified Rankin Scale (mRS), with mRS 3–6 regarded as a poor outcome.**Results:** The mean age was 62.4 ± 12.8 years, and 71.3% had ischaemic stroke. Kidney dysfunction was present in 66.3% of patients (microalbuminuria 41.9%, macroalbuminuria 19.4%, and reduced eGFR 13.1%). Patients with kidney dysfunction had higher median NIHSS scores (14 vs 9; $P < 0.001$), lower admission Glasgow Coma Scale scores ($P = 0.002$), and higher 30-day mortality (31.1% vs 9.3%; $P = 0.002$). Overall 30-day case fatality was 23.8%. On multivariable analysis, albuminuria (adjusted OR 3.21; 95% CI 1.12–9.18) and NIHSS score (AOR 1.13; 95% CI 1.05–1.22) independently predicted death. NIHSS score (AOR 1.21; 95% CI 1.11–1.32) and age predicted poor functional outcome, whereas albuminuria did not. Reduced eGFR was not independently associated with either outcome.**Conclusions:** Albuminuria is common in acute stroke, accompanies greater severity, and independently predicts early mortality. Routine admission urine albumin testing may support early risk stratification.**Keywords:** Acute stroke; Albuminuria; Chronic kidney disease; Glomerular filtration rate; Mortality; NIHSS.This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Introduction**

Stroke remains one of the leading causes of death and long-term disability across the world, and over the last two decades its burden has moved steadily towards low- and middle-income countries [1]. In sub-Saharan Africa, stroke tends to affect people at a younger age, haemorrhagic subtypes are relatively common, and early case fatality is high, reflecting poorly controlled hypertension and limited access to organised acute stroke care [2,3].

A small group of modifiable factors, led by hypertension and followed by diabetes, smoking, dyslipidaemia, and physical inactivity, explains most of the population risk for both ischaemic and haemorrhagic stroke [4]. These same factors drive chronic kidney disease (CKD), so it is not surprising that the kidney and the brain are often

damaged together. Reduced kidney function is associated with a graded rise in cardiovascular events, hospital admission, and death [5], and CKD is now regarded as an independent cardiovascular risk state rather than a simple marker of comorbidity [6]. Both organs are supplied by low-resistance, high-flow vascular beds that are constantly exposed to pulsatile pressure, which may explain why small vessel injury in one organ so often mirrors injury in the other [7]. Two measures are routinely used to describe kidney health.

The estimated glomerular filtration rate (eGFR) reflects filtering capacity, while urinary albumin excretion reflects the integrity of the glomerular barrier. Meta-analyses have shown that an eGFR

below 60 mL/min/1.73 m² raises the risk of incident stroke by roughly 40% (8), and that proteinuria is associated with an even steeper increase in risk [9,10]. Albuminuria is thought to signal widespread endothelial dysfunction, an idea first set out in the Steno hypothesis, in which albumin leakage in the kidney mirrors increased vascular permeability elsewhere in the body [11,12]. Impaired kidney function has also been linked to cerebral small vessel disease and to atrial fibrillation, both of which shape the type and severity of stroke [13,14].

Beyond predicting who develops stroke, kidney dysfunction may influence what happens once a stroke has occurred. Several hospital cohorts have reported that low eGFR or raised serum creatinine at admission is associated with higher mortality and poorer recovery [15-17]. However, these studies were conducted mainly in Europe and Asia, used differing definitions of renal impairment, and seldom examined albuminuria and eGFR side by side. Kidney function can also fall acutely after stroke because of dehydration, infection, or contrast exposure, which complicates the interpretation of a single measurement. It therefore remains uncertain whether the two markers carry equal prognostic weight, and whether kidney dysfunction adds information beyond established clinical predictors such as the National Institutes of Health Stroke Scale (NIHSS).

Data from African populations, where both CKD and stroke are common and frequently detected late, are particularly scarce. The urine albumin-creatinine ratio and serum creatinine are inexpensive, widely available tests that could help clinicians identify high-risk patients early in resource-limited settings. We therefore conducted a prospective study to determine the prevalence of kidney dysfunction among adults admitted with acute stroke to a tertiary hospital, and to examine its relationship with stroke severity at presentation and with mortality and functional outcome at 30 days.

Materials and Methods

Study Design and Setting: This was a prospective observational cohort study carried out in the stroke unit and adult medical wards of a tertiary teaching hospital over a 12-month period.

Sample Size: The minimum sample size was calculated using the Fleiss formula for cohort studies. Assuming a 30-day mortality of 30% among stroke patients with albuminuria and 10% among those without, with a 95% confidence level and 80% power, 123 participants were required. After allowing for 10% attrition, the minimum sample was 137. A total of 160 patients were enrolled.

Study Participants: Consecutive adults aged 18 years and above who presented within 72 hours of symptom onset with a clinical diagnosis of acute stroke, confirmed by non-contrast cranial computed tomography (CT), were recruited. Patients with transient ischaemic attack, stroke mimics (intracranial tumour, subdural haematoma, or head injury), known end-stage kidney disease on dialysis, pregnancy, active urinary tract infection, gross haematuria, menstruation, or fever above 38.5 °C at the time of urine collection were excluded, as were those who declined consent.

Data Collection: A structured proforma was used to record demographic details, vascular risk factors, and admission blood pressure. Level of consciousness was assessed with the Glasgow Coma Scale (GCS), and stroke severity was scored with the NIHSS by a certified physician. Stroke subtype was determined from the admission CT scan.

Laboratory Procedures: A spot urine sample was collected within 24 hours of admission, and the urine albumin-creatinine ratio (UACR) was measured by immunoturbidimetry. Venous blood was analysed for serum creatinine, random blood glucose, and full blood count. eGFR was calculated from serum creatinine using the CKD-EPI creatinine equation.

Definition of Variables: Normoalbuminuria was defined as UACR below 30 mg/g, microalbuminuria as 30–299 mg/g, and macroalbuminuria as 300 mg/g or more. Reduced eGFR was defined as less than 60 mL/min/1.73 m².

Kidney dysfunction was defined as albuminuria, reduced eGFR, or both. Hyperglycaemia was defined as random blood glucose above 140 mg/dL.

Outcome Assessment: The day of admission was taken as day 0. Participants were reviewed on days 7, 14, and 30, in hospital or by structured telephone interview after discharge. Functional status was graded with the modified Rankin Scale (mRS). A score of 0–2 was considered a good outcome, and 3–6 (including death) a poor outcome. The primary outcome was all-cause mortality at 30 days.

Ethical Consideration: Approval was obtained from the institutional Health Research Ethics Committee. Written informed consent was obtained from each participant or, where the patient lacked capacity, from a legally authorised relative. The study followed the principles of the Declaration of Helsinki.

Statistical Analysis: Data were analysed with SPSS version 25.0 (IBM Corp., Armonk, NY). Normality was checked with the Shapiro–Wilk test. Normally distributed variables were summarised as mean ± standard deviation and compared with Student's t-test; skewed variables were presented as

median (interquartile range) and compared with the Mann–Whitney U or Kruskal–Wallis test. Categorical variables were compared with the chi-square or Fisher's exact test, and the chi-square test for trend was used across albuminuria categories. Variables with $P < 0.10$ on univariate analysis, together with clinically important covariates, were

entered into binary logistic regression models for 30-day mortality and poor functional outcome.

Model fit was assessed with the Hosmer–Lemeshow test. A two-sided P value below 0.05 was considered statistically significant.

Results

Table 1: Socio-demographic and clinical characteristics of the study participants (n = 160)

Variable	Frequency (%)
Sex	
Male	86 (53.8)
Female	74 (46.2)
Age	
Mean age (years)	62.4 ± 12.8
<45 years	19 (11.9)
45–64 years	69 (43.1)
≥65 years	72 (45.0)
Risk factors	
Hypertension	141 (88.1)
Diabetes mellitus	37 (23.1)
Alcohol use	29 (18.1)
Dyslipidaemia	24 (15.0)
Previous stroke	18 (11.3)
Current smoking	14 (8.8)
Atrial fibrillation	11 (6.9)
Stroke type	
Ischaemic stroke	114 (71.3)
Intracerebral haemorrhage	42 (26.3)
Subarachnoid haemorrhage	4 (2.5)
Kidney function	
Normoalbuminuria	62 (38.8)
Microalbuminuria	67 (41.9)
Macroalbuminuria	31 (19.4)
Reduced eGFR (<60 mL/min/1.73 m ²)	21 (13.1)
Kidney dysfunction	106 (66.3)
Outcomes	
Mortality by day 7	12 (7.5)
Mortality by day 14	22 (13.8)
Mortality by day 30	38 (23.8)
Poor functional outcome at day 30 (mRS 3–6)	88 (55.0)

eGFR = estimated glomerular filtration rate; mRS = modified Rankin Scale

The study enrolled 160 patients with acute stroke, of whom 86 (53.8%) were men. The mean age was 62.4 ± 12.8 years, and close to half of the participants were aged 65 years or older. Hypertension was by far the most frequent risk factor (88.1%), followed by diabetes mellitus (23.1%) and alcohol use (18.1%). Ischaemic stroke accounted for 71.3% of cases and intracerebral

haemorrhage for 26.3%. Two in every three patients (66.3%) met the definition of kidney dysfunction, driven mainly by albuminuria, while only 13.1% had an eGFR below 60 mL/min/1.73 m². By day 30, 38 patients (23.8%) had died, and 88 (55.0%) had a poor functional outcome (Table 1).

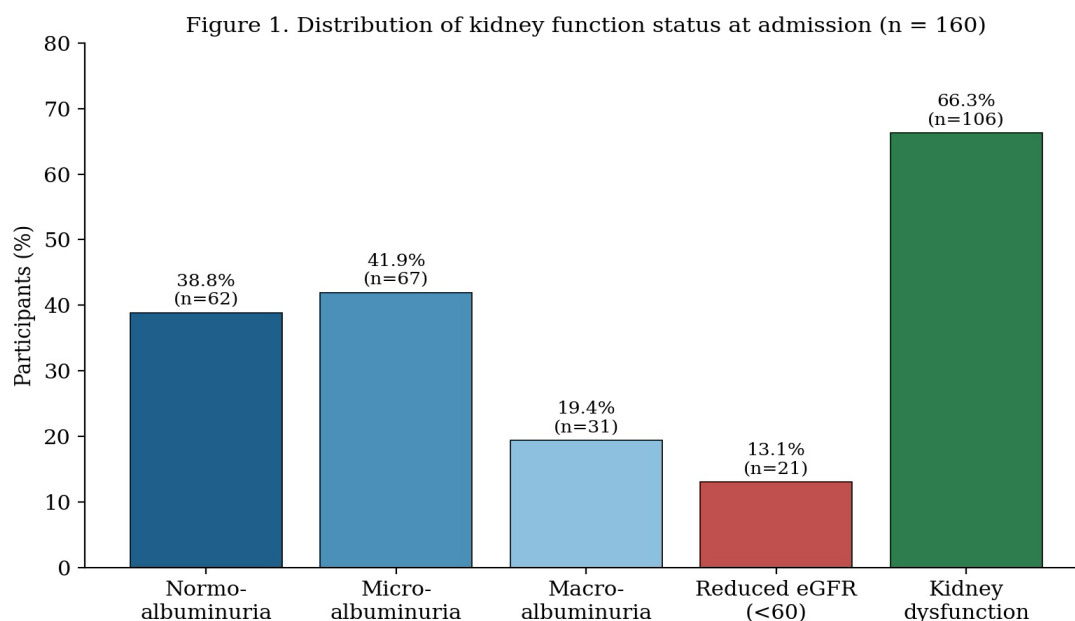


Figure 1: Distribution of kidney function status at admission (n=160)

Figure 1 presents the distribution of kidney function categories at admission.

Microalbuminuria was the single commonest abnormality, found in 41.9% of participants, and a further 19.4% had macroalbuminuria. Normoalbuminuria was observed in 38.8%. A reduced eGFR was far less frequent (13.1%), and most of these patients also had raised albumin

excretion; only eight had a low eGFR with normal urine albumin. Taken together, kidney dysfunction affected 106 patients (66.3%).

The figure highlights that relying on serum creatinine or eGFR alone would have missed most patients with evidence of renal injury, because albuminuria frequently occurred alongside a preserved filtration rate.

Table 2: Comparison of participants with and without kidney dysfunction

Variable	Kidney dysfunction (n = 106)	No kidney dysfunction (n = 54)	P
Age (years), mean $\pm$ SD	63.5 $\pm$ 12.1	60.2 $\pm$ 13.9	0.120
Male sex, n (%)	58 (54.7)	28 (51.9)	0.730
Hypertension, n (%)	97 (91.5)	44 (81.5)	0.060
Diabetes mellitus, n (%)	30 (28.3)	7 (13.0)	0.030
Systolic BP (mmHg), mean $\pm$ SD	168.4 $\pm$ 29.6	159.1 $\pm$ 27.3	0.060
Blood glucose (mg/dL), mean $\pm$ SD	142.6 $\pm$ 68.9	108.3 $\pm$ 41.5	<0.001
Admission GCS, mean $\pm$ SD	12.1 $\pm$ 3.3	13.6 $\pm$ 2.2	0.002
NIHSS score, median (IQR)	14 (8–20)	9 (5–14)	<0.001
eGFR (mL/min/1.73 m ²), mean $\pm$ SD	92.7 $\pm$ 38.4	118.6 $\pm$ 31.2	<0.001
UACR (mg/g), median (IQR)	128.5 (58.0–310.0)	14.2 (8.0–22.0)	<0.001
30-day mortality, n (%)	33 (31.1)	5 (9.3)	0.002
Poor outcome at day 30 (mRS 3–6), n (%)	70 (66.0)	18 (33.3)	<0.001

BP = blood pressure; GCS = Glasgow Coma Scale; NIHSS = National Institutes of Health Stroke Scale; eGFR = estimated glomerular filtration rate; UACR = urine albumin-creatinine ratio; mRS = modified Rankin Scale; SD = standard deviation; IQR = interquartile range

Table 2 compares patients with and without kidney dysfunction. The two groups were similar in age, sex, and systolic blood pressure. Diabetes was more common among patients with kidney dysfunction (28.3% vs 13.0%; $P = 0.030$), and their admission blood glucose was considerably higher. They also presented with more severe strokes,

reflected in a higher median NIHSS score (14 vs 9; $P < 0.001$) and a lower mean GCS (12.1 vs 13.6; $P = 0.002$). As expected, eGFR was lower and UACR markedly higher in this group. Thirty-day mortality was more than three times greater (31.1% vs 9.3%), and poor functional outcome was twice as frequent (66.0% vs 33.3%).

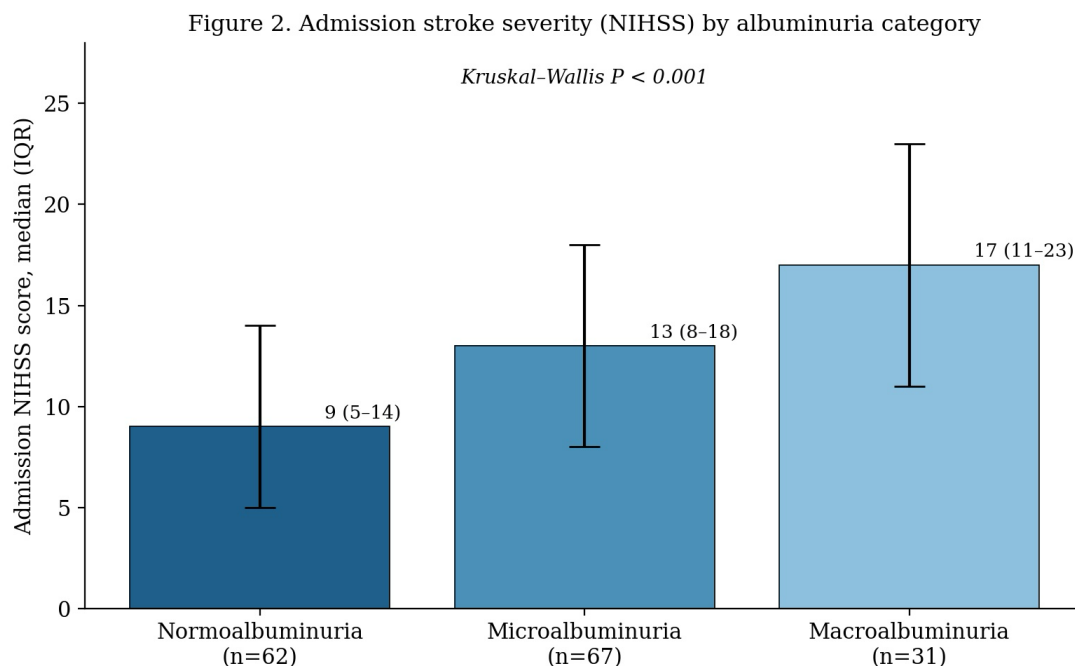


Figure 2: Admission stroke severity (NIHSS) by albuminuria category

Figure 2 displays admission NIHSS scores across the three albuminuria categories.

Stroke severity rose steadily with the degree of albumin excretion. Patients with normoalbuminuria had a median NIHSS score of 9 (IQR 5–14), compared with 13 (IQR 8–18) in those with microalbuminuria and 17 (IQR 11–23) in those with macroalbuminuria. The difference across

groups was statistically significant (Kruskal–Wallis $P < 0.001$).

The overlapping interquartile ranges show that albuminuria does not define severity on its own, but the consistent upward gradient suggests a dose–response relationship between the extent of glomerular and endothelial injury and the neurological deficit seen on arrival.

Table 3: Multivariable logistic regression of predictors of 30-day mortality and poor functional outcome

Predictor	30-day mortality AOR (95% CI)	P	Poor outcome (mRS 3–6) AOR (95% CI)	P
Age (per year)	1.02 (0.98–1.06)	0.310	1.03 (1.00–1.06)	0.048
Admission GCS (per point)	0.89 (0.74–1.07)	0.210	0.91 (0.76–1.09)	0.300
NIHSS score (per point)	1.13 (1.05–1.22)	0.001	1.21 (1.11–1.32)	<0.001
Hyperglycaemia (>140 mg/dL)	1.64 (0.66–4.07)	0.290	1.37 (0.62–3.03)	0.440
Albuminuria (≥ 30 mg/g)	3.21 (1.12–9.18)	0.029	1.86 (0.83–4.17)	0.130
Reduced eGFR (<60)	1.48 (0.47–4.62)	0.500	1.29 (0.44–3.78)	0.640

AOR = adjusted odds ratio; CI = confidence interval; GCS = Glasgow Coma Scale; NIHSS = National Institutes of Health Stroke Scale; eGFR = estimated glomerular filtration rate; mRS = modified Rankin Scale. Hosmer–Lemeshow $P = 0.62$ (mortality model) and 0.48 (functional outcome model).

Table 3 shows the multivariable logistic regression models. After adjustment for age, admission GCS, NIHSS score, hyperglycaemia, and eGFR, albuminuria remained an independent predictor of death within 30 days; patients with albuminuria had roughly three times the odds of dying (AOR 3.21; 95% CI 1.12–9.18). Each one-point rise in NIHSS

score increased the odds of death by 13%. For poor functional outcome, NIHSS score (AOR 1.21) and age (AOR 1.03) were the only independent predictors. Albuminuria showed a positive but non-significant association with disability, and reduced eGFR was not independently related to either outcome. Both models showed good fit.

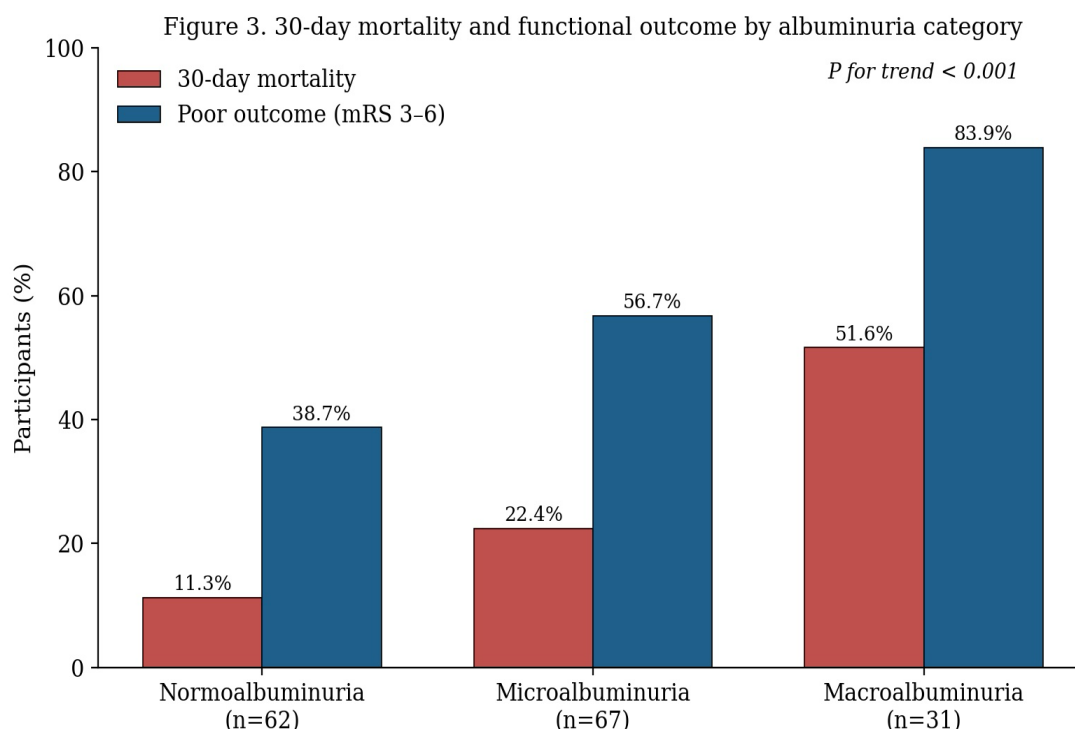


Figure 3: 30-day mortality and functional outcome by albuminuria category

Figure 3 illustrates 30-day outcomes by albuminuria category. Mortality climbed from 11.3% among patients with normoalbuminuria to 22.4% among those with microalbuminuria and 51.6% among those with macroalbuminuria. Poor functional outcome (mRS 3–6, which includes death) followed the same pattern, rising from 38.7% to 56.7% and then to 83.9%. Both trends were highly significant (chi-square test for trend, $P < 0.001$). The steepest change occurred between micro- and macroalbuminuria, where the proportion of deaths more than doubled. These results suggest that the amount of albumin in the urine, and not merely its presence, carries meaningful prognostic information after acute stroke.

Discussion

In this prospective cohort, two-thirds of patients admitted with acute stroke had evidence of kidney dysfunction, mostly in the form of albuminuria. Albuminuria accompanied more severe strokes on arrival and independently predicted death within 30 days, although it did not independently predict functional disability. Reduced eGFR, by contrast, showed no independent link with severity or outcome.

The frequency of microalbuminuria in our cohort is comparable with earlier reports from stroke units in Europe, where between a quarter and a half of patients had raised albumin excretion [18-20]. Our somewhat higher overall figure probably reflects the heavy burden of long-standing, often poorly

treated hypertension in our population, as well as urine collection during the acute phase, when stress responses and hyperglycaemia can transiently increase albumin leakage [18]. The stepwise rise in NIHSS score from normo- to macroalbuminuria supports the view that albuminuria reflects the health of the wider vascular tree. Słowik and colleagues found that microalbuminuria in non-diabetic ischaemic stroke was associated with larger deficits and higher early mortality [19], and Turaj et al. described similar prognostic value [20]. In a large Japanese registry, proteinuria was linked to neurological deterioration and poor outcome independent of other factors [21], and Kanamaru et al. reported that albuminuria predicted early worsening in acute ischaemic stroke [22]. Chen et al. further showed that proteinuria predicted an unfavourable outcome even in patients who received intravenous thrombolysis [23]. The threefold odds of death seen with albuminuria in our study fit well with this body of evidence. Higher blood glucose in the albuminuria group may have contributed, since stress hyperglycaemia is itself associated with poorer stroke prognosis [24]; however, albuminuria remained significant after adjustment for glucose.

The absence of an independent association between albuminuria and functional outcome most likely reflects the dominant influence of initial stroke severity. Because the NIHSS score lies partly on the pathway between vascular injury and later disability, adjusting for it may absorb much of the effect of albuminuria. Reduced eGFR was

uncommon and did not predict outcome, and published evidence on this point is mixed. The Rotterdam Study linked low eGFR more closely to haemorrhagic than to ischaemic stroke [25], while hospital cohorts from Israel and China reported worse short-term prognosis in patients with CKD [16,26], and MacWalter et al. found that impaired renal function predicted long-term mortality [15].

The small number of patients with low eGFR in our study limited statistical power, and the exclusion of patients on dialysis removed those at highest risk. A single creatinine value in the acute phase may also be influenced by dehydration or acute kidney injury, which carries its own prognostic weight after stroke [27].

The 30-day case fatality of 23.8% lies within the range reported from other tertiary hospitals in sub-Saharan Africa [28]. From a practical point of view, the urine albumin-creatinine ratio is cheap and quick to obtain.

Measuring it at admission could help flag patients who need closer observation, careful blood pressure and glucose control, and early nephrology input, in keeping with calls for integrated care of patients with coexisting kidney and cerebrovascular disease [29]

Limitation

This single-centre study had a modest sample size and only 30 days of follow-up. Kidney function was measured once during the acute phase, so persistent albuminuria and chronic kidney disease could not be confirmed. Pre-stroke kidney function was unknown, and residual confounding cannot be fully excluded.

Conclusion

Kidney dysfunction, mainly in the form of albuminuria, was present in two out of three adults admitted with acute stroke. Patients with albuminuria had more severe neurological deficits on arrival, and albuminuria independently predicted death within 30 days, with risk rising sharply at the macroalbuminuric level. Reduced eGFR was uncommon and did not independently predict severity, mortality, or disability, while the initial NIHSS score remained the strongest determinant of functional outcome. Measuring the urine albumin-creatinine ratio at admission is simple and inexpensive and could be built into routine stroke assessment. Larger multicentre studies with longer follow-up are needed to confirm these findings.

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