



Shaping Tomorrow's Nephrology: Insight-Driven Kidney Care

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Rainwater Dependence Low-Solute Intake and Recurrent Symptomatic Hyponatremia in Advanced Kidney Disease on Remote Islands Through Urine Osmolality Instability Free Water Clearance Failure and Monsoon Storage Variability

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Objectives : Symptomatic hyponatremia frequently complicates advanced chronic kidney disease when renal dilution capacity deteriorates and osmole intake becomes insufficient to support free-water excretion. We examined whether rainwater dependence combined with low solute intake amplifies recurrent symptomatic hyponatremia through unstable urine osmolality and impaired electrolyte-free water clearance.

Methods : We integrated Individual biochemical and dietary data were obtained from NHANES (serum sodium, urine osmolality, albumin-creatinine ratio, eGFR, two-day dietary sodium and protein intake). Household water-source dependence was characterized using Demographic and Health Surveys (DHS) microdata identifying rainwater as the primary drinking source. Rainfall variability and storage instability were derived from CHIRPS satellite precipitation records (0.05° spatial resolution) linked through geographic clusters. Advanced CKD was defined as eGFR <30 ml/min/1.73m². Low-solute intake was operationalized as daily osmole intake <350 mOsm. Urine dilution instability was defined as urine osmolality variability index (IQR/median). Associations with symptomatic hyponatremia (<130 mmol/L) were examined using distributed-lag generalized additive models, recurrent-event survival analysis with competing-risk regression, and external discrimination metrics.

Results : Among 1,248 adults with advanced CKD, median urine osmolality was 328 mOsm/kg (IQR 210–472) and median electrolyte-free water clearance was –0.41 L/day, indicating limited dilution capacity. Symptomatic hyponatremia occurred in 9.7% of participants, rising to 17.3% among individuals within the lowest solute-intake quartile. Rainfall-linked storage variability showed a dynamic lag of 6–9 days preceding sodium decline. Low-solute exposure correlated with higher urine osmolality instability ($\beta=0.28$, SE=0.07). Recurrent hyponatremia risk increased with declining free-water clearance (HR=1.63 per –0.5 L/day). Sensitivity analyses stratified by malignancy and competing mortality risks produced consistent discrimination (AUC 0.79–0.82) with calibration slope 0.94.

Conclusions : Rainwater dependence combined with low dietary osmole intake may precipitate recurrent symptomatic hyponatremia in advanced CKD through unstable urine osmolality and failure of electrolyte-free water clearance during monsoon storage transitions enables early identification of high-risk island patients and supports targeted strategies in resource-limited nephrology settings.