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Original Research Paper

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A COMPARATIVE ANALYSIS OF XEROSTOMIA, SERUM OSMOLALITY, AND INTERDIALYTIC WEIGHT GAIN IN HEMODIALYSIS PATIENTS RECEIVING CALCIUM CHANNEL BLOCKERS VS NON CALCIUM CHANNEL BLOCKERS : A CROSS-SECTIONAL STUDY

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ABSTRACT Xerostomia is a common yet under-recognized symptom among patients undergoing maintenance hemodialysis and may contribute to excessive fluid intake and interdialytic weight gain (IDWG). Calcium channel blockers (CCBs), frequently prescribed for hypertension in this population, may aggravate xerostomia by reducing salivary secretion. This cross-sectional study compared xerostomia severity, serum osmolality, and IDWG between 206 maintenance hemodialysis patients receiving CCBs (n = 103) and non-CCB antihypertensive therapy (n = 103). Xerostomia was assessed using the Xerostomia Inventory Scale, and serum osmolality was calculated from serum sodium, glucose, and blood urea nitrogen. Patients receiving CCBs had significantly higher xerostomia scores, serum osmolality, and IDWG than the non-CCB group ($p < 0.001$). Xerostomia showed a significant positive correlation with IDWG in both groups, whereas serum osmolality was not significantly associated with xerostomia. These findings suggest that CCB-associated xerostomia may contribute to increased fluid gain in maintenance hemodialysis patients.

KEYWORDS : Hemodialysis; Xerostomia; Calcium channel blockers; Interdialytic weight gain

INTRODUCTION

Maintenance hemodialysis is the main treatment for patients with end-stage kidney disease; however, it frequently disturbs fluid and electrolyte balance, which can negatively affect clinical outcomes and overall quality of life [1][2][3]. One of the major difficulties in managing hemodialysis patients is interdialytic weight gain (IDWG), which reflects fluid accumulation between dialysis sessions and it is closely associated with hypertension, intradialytic complications, and increased mortality [1][2][4]. Despite strict fluid restrictions and continuous dietary counseling, many patients continue to have excessive IDWG, indicating that both physiological and behavioral factors influencing fluid intake remain poorly controlled in this population [1]

Thirst and xerostomia are major contributors to excessive fluid intake in hemodialysis patients [5][6]. Dry mouth is frequently seen in the ESRD patients and it is associated with reduced salivary flow, oral discomfort, difficulty in chewing and swallowing, altered taste sensation, and a decline in oral health- related quality of life [7][8][9]. Several factors contribute to xerostomia, including uremia, dehydration, aging, polypharmacy, prolonged dialysis, and associated co morbid conditions [7][8]. Reduced salivary secretion has been associated with xerostomia and higher interdialytic weight gain in previous studies [5][6].previous studies have reported associations between xerostomia severity and interdialytic weight gain, highlighting the significant role of salivary function in fluid regulation among dialysis patients [5][6][10].

In chronic kidney disease, salivary gland dysfunction can be detected through complaints of dry mouth and through objective measurements of salivary secretion [11].hemodialysis itself can cause difference in salivary flow, composition, and oral mucosal integrity, which may contribute to constant sensation of dry mouth- even in the absence of obvious dehydration. This suggests that structural and functional changes in the salivary glands, rather than fluid restriction alone, play a role in xerostomia among dialysis patients [12][13].

Calcium channel blockers (CCBs) are commonly recommended antihypertensive medications in patients with chronic kidney disease and those undergoing hemodialysis because of their successful blood pressure control and cardiovascular benefits [14][15][16][17]. However, these drugs can interfere with calcium-dependent signaling mechanisms in the salivary glands, leading to lower baseline salivary secretion and an increased risk of medication-induced xerostomia [16]. Therefore , patients receiving CCBs may have more severe dry mouth compared to those on other classes of antihypertensive, which may further aggravate the symptoms of xerostomia[7][16].

Serum osmolality, which is primarily affected by sodium, glucose, and urea concentrations, plays an important role in the body water homeostasis [17]. In patients undergoing hemodialysis, changes in post dialysis serum sodium and overall osmolality have been associated with increased thirst sensation and higher interdialytic weight gain (IDWG). This relationship highlights the close interaction between biochemical parameters and fluid regulation in the hemodialysis population [18][19].

Non-medicinal intervention, like chewing gum and psychological strategies aimed at controlling thirst, have shown beneficial effects by increasing salivary flow and reducing xerostomia in patients on hemodialysis [19][20]. These results highlight salivary health's practical importance in fluid control and position medication-induced dry mouth as a target for intervention.

While CCB-linked xerostomia is acknowledged, few studies have jointly assessed CCB use, xerostomia intensity, biochemical markers (like serum osmolality), and IDWG in maintenance hemodialysis patients [7][10][21][22]. Earlier work often separate these factors rather than integrating them comparatively.

Therefore, this study performs a cross-sectional comparison of xerostomia, biochemical profiles, and fluid status in hemodialysis patients on CCBs versus non-CCBs. It looks to

explain how antihypertensive choices interact with oral symptoms, biochemical control, and fluid equilibrium in this population.

Aim:

To compare xerostomia severity, serum osmolality, and interdialytic weight gain between hemodialysis patients receiving calcium channel blockers and those receiving non-calcium channel blocker therapy.

OBJECTIVES

- To compare the severity of xerostomia between patients receiving calcium channel blockers and those receiving non-calcium channel blockers
- To compare serum osmolality levels between the two patient groups
- To compare interdialytic weight gain across the two groups
- To assess the relationship among xerostomia severity, serum osmolality and interdialytic weight gain

Study Design And Settings

This cross sectional study was conducted at tertiary care dialysis centre between August 2025 and January 2026

Study Population

Adult patients undergoing maintenance hemodialysis

Inclusion Criteria

- Participants aged 18 years or above
- Undergoing maintenance hemodialysis for a minimum duration of three months
- Receiving treatment with either calcium channel blockers or non-calcium channel blockers including ARBs, Beta blockers, ACE inhibitors, and alpha blockers

Exclusion Criteria

- Presence of an active infection or recent hospitalization
- History of salivary gland disorders
- Diagnosis of Sjögren's syndrome
- History of head and neck radiation therapy
- Use of medications, other than antihypertensive agents, known to alter salivary secretion

Sample Size

The sample size was calculated based on previously published data by Bellomo et.al (2015), which reported differences in interdialytic weight gain between patients receiving calcium channel blockers and those not receiving CCB therapy. With a confidence level of 90% and a statistical power of 80%, the minimum required sample size was estimated to be 103 patients in each group

Data Collection

- Demographic and clinical information were obtained from medical records
- Patients receiving CCB were predominantly treated with dihydropyridine (DHP) agents such as Amlodipine. Non-dihydropyridine agents such as Diltiazem or Verapamil were not commonly prescribed in our dialysis unit
- Patients in the non-CCB group were receiving various antihypertensive agents, including ARBs,beta-blockers, ACE inhibitors, and alpha blockers. Information regarding all concomitant medication was not uniformly available and was therefore not included in the analysis
- The dialysate sodium concentration was maintained between 138 and 140 mmol/L. Sodium modeling was not routinely used in our dialysis unit
- Xerostomia severity was evaluated using the xerostomia inventory scale[1]
- Pre and post dialysis weights from last three dialysis sessions were recorded to determine the average IDWG[10]
- IDWG was also expressed as a percentage of dry body weight using the formula: IDWG%= (IDWG in kg/dry body weight in kg)*100
- Serum sodium, glucose, and blood urea nitrogen levels were recorded and used to estimate serum osmolality[8]

Calculation Of Serum Osmolality

Serum osmolality was estimated by the formula:
Serum osmolality=2×[Na]+Glucose/18+BUN/2.8

Statistical Analysis

Analysis of the data was executed using statistical software. Continuous variables were shown as mean ± standard deviation. A comparison between groups was done using the independent sample t-test. The association between xerostomia severity, serum osmolality, and interdialytic weight gain were assessed using Pearson correlation analysis. A p-value of less than 0.05 was considered statistically significant. Multivariate linear regression analysis was performed to identify independent predictors of IDWG, adjusting for CCB use, xerostomia severity, serum osmolality, age, gender, diabetes mellitus, and hypertension.

RESULTS

A total of 206 patients were enrolled, with 103 participants in CCB and non CCB groups

Baseline demographic and clinical characteristics of the study population showed no statistically significant difference between the groups with respect to age distribution, sex, hypertension, or coronary artery disease ($p>0.05$)

Group Comparison

- Xerostomia severity was significantly greater in the calcium channel blocker group (26.42±10.22) compared with non-calcium channel blocker group (15.07±4.56;$p<0.001$).
- Interdialytic weight gain was also significantly higher among patients receiving calcium channel blockers (3.65±1.01kg) than in those receiving non-calcium channel blockers (2.33±1.07kg: $p<0.001$)
- Serum osmolality was markedly elevated in the calcium channel blocker group (300.52±7.37mosm/kg) relative to the non calcium channel blocker group (290.97±6.26mOsm/kg; $p<0.001$)
- Additionally, serum sodium, blood urea nitrogen, and glucose levels were significantly higher in the calcium channel blocker group
- Multivariable linear regression analysis demonstrated that CCB use and xerostomia score were independently associated with IDWG after adjustment for age, sex, diabetes mellitus, hypertension, and serum osmolality.

Correlation Analysis

In the calcium channel blocker group, xerostomia severity demonstrated a moderate positive correlation with interdialytic weight gain($r=0.539$,$p<0.001$). No significant associations were found between serum osmolality and either xerostomia severity or interdialytic weight gain in both groups.

RESULTS

A Comparative Analysis of Xerostomia, Serum Osmolality, and Interdialytic Weight Gain in Hemodialysis Patients on CCB versus Non-CCB

The Baseline Demographic and Clinical Characteristics of the Participants are presented in Table 1

Variable	CCB Group (n=103)	Non-CCB Group (n=103)	Chi-square	p-value
Age ≤30 years	5 (4.9%)	6 (5.8%)	0.734	0.865
Age 31–40 years	8 (7.8%)	8 (7.8%)	—	—
Age 41–50 years	15 (14.6%)	19 (18.4%)	—	—

Age >50 years	75 (72.8%)	70 (68.0%)	—	—
Male	63 (61.2%)	70 (68.0%)	1.040	0.308
Female	40 (38.8%)	33 (32.0%)	—	—
Diabetes Mellitus	46 (44.7%)	45 (43.7%)	0.020	0.888
Hypertension	79 (76.7%)	69 (67.0%)	2.400	0.121
Coronary Artery Disease	27 (26.2%)	22 (21.4%)	0.669	0.413

All comparisons by Chi-square test. No statistically significant differences between groups (all p > 0.05). Groups are comparable at baseline.

The Comparison of Clinical and Biochemical Parameters Between CCB and Non-CCB Groups is presented in Table 2

Variable	CCB Group Mean ± SD	Non-CCB Group Mean ± SD	Mean Difference	t-value	p-value
XIS Score	26.42 ± 10.22	15.07 ± 4.56	11.35	10.291	<0.001
IDWG (%)	6.30 ± 1.80	3.86 ± 1.82	2.44	9.707	<0.001
Serum Osmolality (mOsm/kg)	300.52 ± 7.37	290.97 ± 6.26	9.55	10.025	<0.001
BUN (mg/dL)	47.66 ± 18.45	41.61 ± 16.28	6.05	2.495	0.013
Serum Sodium (mEq/L)	137.34 ± 3.03	134.36 ± 5.43	2.98	4.865	<0.001
Glucose (mg/dL)	155.43 ± 77.55	124.42 ± 61.18	31.01	3.186	0.002

All comparisons by independent samples t-test. All parameters showed statistically significant differences (p < 0.05). IDWG = Interdialytic Weight Gain; XIS = Xerostomia Inventory Scale; BUN = Blood Urea Nitrogen.

Correlation Analysis between xerostomia severity and biochemical parameters is presented in Table 3

Correlation Pair	Group	r-value	p-value
XIS Score vs IDWG (%)	CCB	0.539	<0.001**
XIS Score vs Serum Osmolality	CCB	0.157	0.112(ns)
IDWG (kg) vs Serum Osmolality	CCB	0.003	0.976(ns)
XIS Score vs IDWG (%)	Non-CCB	0.321	0.001**
XIS Score vs Serum Osmolality	Non-CCB	0.146	0.142(ns)
IDWG (kg) vs Serum Osmolality	Non-CCB	0.075	0.450(ns)

*** Significant at p < 0.01 (2-tailed). ns = not significant. XIS = Xerostomia Inventory Scale; IDWG = Interdialytic Weight Gain.*

The multivariable linear regression analysis is presented in Table 4

Variable	β	SE	95% CI Lower	95% CI Upper	t-value	p-value
CCB use (vs Non-CCB)	1.387	0.347	0.706	2.068	3.996	<0.001 ***
XIS Score	0.087	0.015	0.057	0.117	5.800	<0.001 ***
Serum Osmolality	-0.015	0.018	-0.049	0.019	-0.833	0.398 (ns)
Age	-0.121	0.178	-0.469	0.227	-0.680	0.497 (ns)
Gender	0.345	0.248	-0.142	0.832	1.391	0.167 (ns)
Diabetes Mellitus	-0.270	0.255	-0.770	0.229	-1.059	0.290 (ns)
Hypertension	0.317	0.321	-0.312	0.947	0.988	0.324 (ns)

*** p < 0.001. ns = not significant. Dependent variable: Interdialytic Weight Gain (kg). Model adjusted for CCB use, XIS score, serum osmolality, age, gender, diabetes mellitus, and hypertension. Green shading = statistically significant independent predictor*

DISCUSSION

This study was conducted as a cross-sectional study compared xerostomia severity, biochemical markers, and fluid status in hemodialysis patients on calcium channel blockers (CCBs) versus non-CCB antihypertensive. Results demonstrated that CCB use was associated with more severe xerostomia, higher interdialytic weight gain (IDWG), and increased serum osmolality indicating an interrelationship between antihypertensive variety, oral discomfort, and fluid control in maintenance hemodialysis [14][16][5][18].

Patients on calcium channel blockers showed significantly elevated xerostomia inventory scores compared to those treated with non-CCB antihypertensive. This finding supports existing evidence that CCBs interfere with calcium-dependent signaling in the salivary glands, resulting in decreased resting salivary secretion and cause dry mouth [16][17]. Beyond dialysis related factors like uremia, polypharmacy, and salivary gland alterations, our results show that CCB therapy further aggravates xerostomia rather than acting as neutral factor [7][8][12].

The major findings of this study was the significantly higher interdialytic weight gain (IDWG) seen in patients receiving calcium channel blockers. In this group, a moderate positive correlation was discovered between xerostomia severity and IDWG ($r = 0.539$, $p < 0.001$), indicating that xerostomia was significantly associated with IDWG. Even though thirst is influenced by multiple physiological and behavioral factors . This observation is consistent with past studies that have shown a close relationship between xerostomia, and interdialytic weight gain in patients on hemodialysis [5][6][10][21].

Importantly multivariate regression confirmed that CCB use and xerostomia severity remained independent predictors of IDWG after adjusting for age, gender, diabetes mellitus, and hypertension, underscoring the clinical relevance of medication induced dry mouth in fluid management

From a biochemical point of view, patients receiving calcium channel blockers showed higher mean levels of serum sodium, blood urea nitrogen, glucose, and calculated serum osmolality compared to those in the non-CCB group. Elevated serum osmolality reflects a more concentrated plasma state and reflects alterations in body water homeostasis [17]. In patients on CCB therapy, this biochemical pattern may be associated with differences in fluid status, particularly among individuals with altered salt taste perception [17][18][22].

Particularly, serum osmolality did not show a direct association with either xerostomia severity or interdialytic weight gain in both groups. Serum osmolality did not show a significant association with xerostomia severity or IDWG in either group. Although serum osmolality is an important determinant of body water homeostasis, xerostomia showed a stronger association than serum osmolality.

From a clinical perspective, these findings are important. The choice of antihypertensive medication appears to affect not only blood pressure control but also oral health and overall fluid status in hemodialysis patients [14][15][23]. Regular screening for xerostomia particularly among patients receiving calcium channel blockers may help identify individual set increased risk of excessive interdialytic weight gain [7][10]. In addition, Simple intervention such as salivary stimulants (for example chewing gum or saliva substitutes) may improve oral comfort and quality of life[19][20].

This study has several limitations. This cross sectional design does not allow casual relationship to be confirmed or evaluation of the effects of substituting calcium channel blockers on clinical outcomes. Dietary sodium intake was not properly assessed in this study.In addition, objective measurements of salivary flow were not included. In addition,

residual confounding related to concomitant medications and dialysis related variables cannot be completely excluded Furthermore, thirst intensity and actual fluid intake were not directly measured, despite being discussed as potential mediators of the association between xerostomia and IDWG. Future longitudinal studies combining both subjective assessments and objective salivary measurements, along with assessment of medication adjustments, are required to better clarify these relationships [11][12].

In summary, hemodialysis patients receiving calcium channel blockers experience more severe xerostomia, higher interdialytic weight gain, and increased serum osmolality compared with those treated with non-CCB antihypertensive agents. The observed association between xerostomia severity and IDWG highlights the potential importance of oral symptoms in hemodialysis patients

CONCLUSION:

Hemodialysis patients receiving calcium channel blockers demonstrated significantly higher xerostomia scores, greater interdialytic weight gain, and increased serum osmolality compared with non CCB users. Xerostomia severity was positively associated with IDWG. However, owing to the cross sectional design, casual relationships cannot be established, and prospective studies are required to confirm these findings.

Consent to Publish: Not applicable
Code Availability: No custom code or software was used in this study

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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