ISSN: 3065-7628

Research Article

Journal of Future Medicine and Healthcare Innovation

Secondary Hyperparathyroidism in Chronic Hemodialysis Patients: Prevalence, Complications, and Challenges in à Resource-Limited Setting

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Submitted: 2025, Sep 25; **Accepted:** 2025, Oct 16; **Published:** 2025, Oct 30

Citation: Guesmi, R., Jellali, Z. (2025). Secondary Hyperparathyroidism in Chronic Hemodialysis Patients: Prevalence, Complications, and Challenges in a Resource-Limited Setting. *J Future Med Healthcare Innovation, 3*(2), 01-05.

Abstract

Introduction: *Secondary hyperparathyroidism (SHPT) is a serious complication of end-stage renal disease. Despite its high morbidity and mortality, it remains a controllable condition if managed early.*

Methods: *We conducted a cross-sectional study at the hemodialysis unit of Sidi Bouzid hospital. All patients undergoing hemodialysis for more than six months were included. Clinical, biochemical, and therapeutic data were collected and analyzed.*

Résults: *A total of 94 patients were included. SHPT was present in approximately 60% of patients. More than 50% of patients suffered from bone demineralization, pruritus, vascular calcifications, and resistant anemia. None of the patients received calcimimetics or non-calcium phosphate binders. However, 80% were on calcium-based phosphate binders, and 7% underwent subtotal parathyroidectomy.*

Conclusion: *SHPT affects more than half of our dialysis population and is associated with severe complications. In low-income countries with limited treatment options, innovative approaches such as artificial intelligence could help improve disease management and patient outcomes.*

Keywords: Hemodialysis, Secondary Hyperparathyroidism, Calcimimetics, Phosphore Binders and Artificial Intelligence

1. Introduction

Secondary hyperparathyroidism (SHPT) is a common and serious complication in patients with chronic kidney disease (CKD), especially those undergoing maintenance hemodialysis. It results from impaired phosphate excretion, reduced calcitriol synthesis, increased fibroblast growth factor (FGF) 23 and hypocalcemia, leading to parathyroid gland hyperplasia and increased parathyroid hormone (PTH) secretion **[1]**.

SHPT contributes to a broad spectrum of complications, including renal osteodystrophy, vascular calcifications, anemia resistant to erythropoisis stimulating agents (ESA), and increased cardiovascular morbidity and mortality **[2,3]**.

Despite the availability of international guidelines such as those from KDIGO (Kidney Disease: Improving Global Outcomes) **[4]**, the implementation of adequate diagnostic and therapeutic strategies remains challenging in low-income settings **[2]**. Calcimimetics and non-calcium phosphate binders, which are standard treatments in developed countries, are often unavailable or unaffordable in resource-limited regions **[5]**. Consequently, SHPT is often diagnosed late and poorly controlled, increasing the burden on patients and healthcare systems.

In Tunisia and other similar contexts, little data exists on the real-world burden and management of SHPT in chronic dialysis populations. Understanding the prevalence, complications, and therapeutic gaps is essential to improve outcomes.

This study aims to assess the prevalence and complications of SHPT and identify management challenges in a chronic hemodialysis unit within a resource-constrained healthcare setting.

2. Methods

2.1. Study Design and Setting

We conducted a descriptive cross-sectional study in the chronic hemodialysis unit of the regional hospital of Sidi Bouzid, Tunisia. This is a public hospital located in a medically underserved area, with limited access to advanced nephrology therapies.

2.2. Study Population

All adult patients undergoing regular hemodialysis for more than six months were eligible. Exclusion criteria included patients with less than six months of follow-up, or those with incomplete laboratory data related to mineral metabolism.

2.3. Data Collection

Data were collected through medical records and direct patient interviews. The following variables were analyzed :

- Demographics : age, sex, duration of dialysis
- Clinical parameters : etiology of renal failure, comorbidities
- Biochemical data : serum levels of parathyroid hormone (PTH), calcium, phosphate, hemoglobin
- Complications related to SHPT : bone pain or fractures, pruritus, vascular calcifications, gait disorders, anemia
- Therapies used : phosphate binders (calcium-based vs non-calcium), vitamin D analogs (alpha-calcidol), calcimimetics, parathyroidectomy
- SHPT was defined according to KDIGO criteria as a persistently elevated PTH level in the range of approximately 2 to 9 times the upper normal limit for the assay **[4]**.

2.4. Statistical Analysis

Descriptive statistics were used to summarize patient characteristics and outcomes. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as means ± standard deviation. The chi-square test and Student's t-test were used to explore associations between SHPT and clinical or biological variables. A p-value < 0.05 was considered statistically significant.

3. Results

Variable	Value
Number of patients	94
Mean age (years)	51.5 ± 13.2
Male sex (%)	57%
Duration on dialysis (years, median)	6.8
SHPT prevalence	59.6%
Main ESRD etiologies (in SHPT patients)	Interstitial nephropathy (41%), Diabetic nephropathy (28%)
SHPT was diagnosed in 56 patients	

Table 1: General Characteristics of the Study Population

3.1. Patient Characteristics (Table 1)

A total of 94 chronic hemodialysis patients were included in the study. The mean age was 51.5 ± 13.2 years, and 57% were male. The median duration of dialysis was 6.8 years (range: 0.5–18 years). Only 40% of the patients had 3 HD sessions per week.

3.2. Prevalence of SHPT (Table 1)

SHPT was diagnosed in 56 patients (59.6%) based on persistently elevated PTH levels. The primary causes of end-stage renal disease (ESRD), in these patients, were chronic interstitial nephropathy (41%) and diabetic nephropathy (28%).

Feature	This Study	Literature	References
Prevalence of SHPT	56.9%	49.5% (95% CI: 30.2–68.2%)	Frontiers in Endocrinology, 15 **5**
Dialysis duration	Significantly longer in SHPT group	Recognized risk factor	Tentori et al., 2008 **6**
Age	No significant difference	Often younger patients	Tentori et al., 2008 **6**
Sex	No significant association	Variable results	Tentori et al., 2008 **6**

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Low socioeconomic level	Not significantly associated	Potential factor	KDIGO 2017 Guidelines **4**
Non-adherence	Not significantly associated	Associated with SHPT	Block et al., 2004 **3**

Table 2: General Characteristics Between SHPT and Non SHPT Groups and Comparison with Littérature

3.3. Comparison Between Patients With and Without SHPT (Table 2)

We further compared the studied demographic and clinical characteristics between SHPT and non-SHPT patients, and confronted our results with existing literature data (Table 3). Only, the dialysis duration was found significantly higher in the SHPT group.

Complications	
Bone Pain	85%
Bone demineralization	54%
Pruritus	51%
Vascular calcifications	48%
Resistant anemia	45%
Gait disorders	22%
Treatments	
Alpha-calcidol use	30%
Calcium-based phosphate binders	80%
Parathyroidectomy	7%
Non-calcium phosphate binders	0%
Calcimimetic use	0%

Table 3 : SHPT-Related Complications and Treatment Patterns

3.4. SHPT-Related Complications (Table 3)

More than half of the patients with SHPT exhibited at least one complication. The most frequently reported complications were:

- Bone demineralization (54%)
- Pruritus (51%)
- Vascular calcifications (48%)
- Resistant anemia (45%)
- Gait disorders (22%)

3.5. Treatment Patterns (Table 3)

- None of the patients received calcimimetics.
- None received non-calcium-based phosphate binders.
- 80% of patients were treated with calcium-based phosphate binders.
- 30% received alpha-calcidol as vitamin D analog therapy.
- 7% underwent subtotal parathyroidectomy (7/8th) in cases of resistant SHPT, defined by a persistent parathyroid hormone (PTH) level exceeding 9 times the upper limit after more than 6 months of optimal medical treatment.

4. Discussion

Secondary hyperparathyroidism (SHPT) remains a common and serious complication in patients undergoing chronic hemodialysis. In our cohort, nearly 60% of patients had biochemical evidence of SHPT, a prevalence consistent with reports from other low-resource settings **[2]**. This high burden highlights the ongoing challenges in achieving adequate mineral bone disorder (MBD) control, particularly in environments with limited therapeutic options.

Our results confirm the strong association between SHPT and multiple complications, including bone demineralization, vascular calcifications, resistant anemia, pruritus, and gait disturbances. These complications not only reduce quality of life but also contribute to increased morbidity and mortality **[3,6]**.

Therapeutic strategies were severely limited. None of our patients received calcimimetics or non-calcium phosphate binders, cornerstones of modern SHPT management in higher-income settings. Instead, 80% of patients received calcium-based phosphate binders, only 30% were treated with active vitamin D analogs, because of an uncontrolled hyperphosphatemia, and 7% underwent subtotal parathyroidectomy. This therapeutic gap likely contributes to the persistence and severity of SHPT observed in our population. The use of calcium-based binders, while affordable and accessible, is associated with a greater risk of vascular calcification, especially in the absence of calcimimetics **[7]**.

Several barriers explain this suboptimal management, including lack of access to essential medications, limited laboratory monitoring, and economic constraints. These challenges are not unique to our center and have been reported across various low-income

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countries **[8]**. Innovative and scalable solutions are needed.

Addressing SHPT in low-resource settings requires more than just increasing drug availability, it calls for innovative strategies to optimize diagnosis, risk stratification, and treatment adherence. In this context, artificial intelligence (AI) offers promising solutions.

AI-powered clinical decision support tools can assist nephrologists in early identification of patients at risk for SHPT, using routinely collected dialysis data such as serum calcium, phosphate, PTH trends, and treatment history. Predictive algorithms could help anticipate SHPT onset before complications arise, prompting earlier intervention.

Moreover, AI can enhance treatment optimization by suggesting personalized therapeutic adjustments based on individual profiles **[9]**, improving the balance between calcium load, phosphate control, and PTH suppression, even in the absence of specialized nephrology training. Machine learning systems have already shown potential in managing anemia **[10]**, and cardiovascular risks in dialysis patients **[11]**, and similar models could be developed for SHPT management.

Another area of promise is treatment adherence. AI-integrated mobile applications or chatbots could support patient education, track phosphate binder use, and reinforce vitamin D supplementation schedules, particularly in populations with low health literacy.

Finally, AI could facilitate resource allocation and policy planning, helping health systems identify care gaps and prioritize cost-effective interventions for chronic kidney disease–mineral and bone disorder (CKD-MBD) management at the population level.

Although the integration of AI into routine dialysis care still faces challenges, such as data quality, digital infrastructure, and clinician acceptance, its role in narrowing the global nephrology care gap is undeniable. Future research should explore the implementation and real-world effectiveness of AI-assisted SHPT management strategies in resource-constrained environments.

5. Conclusion

Secondary hyperparathyroidism affects more than half of our chronic hemodialysis patients and is associated with serious clinical complications such as bone disease, pruritus, vascular calcifications, and anemia. The therapeutic arsenal remains limited in low-resource settings, where access to calcimimetics and non-calcium phosphate binders is often restricted. In this context, leveraging artificial intelligence could represent a valuable tool to improve early detection, guide individualized treatment decisions, and enhance adherence strategies. Addressing SHPT effectively will require not only broader access to essential therapies but also the integration of innovative, scalable technologies adapted to constrained health systems.

Conflicts of interest

Authors declared they have no conflicts of interest

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author's Contribution

Conception and Study Design: Rahma Guesmi
Data Collection: Rahma Guesmi, Zohra Sassi Jallali
Data Analysis and Interpretation: Rahma Guesmi
Manuscript Drafting: Rahma Guesmi
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Manuscript Revision: Zohra Sassi Jallali
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All authors read and approved the final version of the manuscript.

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