



Comparative Analysis of Dermatological Manifestations in Chronic Renal Failure Patients With and Without Hemodialysis

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Abstract

Chronic renal failure (CRF) is frequently associated with a wide range of cutaneous manifestations resulting from metabolic disturbances, toxin accumulation, and treatment-related factors. This study aimed to compare the prevalence and characteristics of dermatological manifestations in patients with CRF undergoing hemodialysis and those not yet on dialysis. A cross-sectional observational study was conducted on 120 adult patients diagnosed with CRF, divided into two groups: 60 receiving maintenance hemodialysis for at least six months and 60 managed conservatively without dialysis. Detailed dermatological examinations were performed by certified dermatologists, and relevant biochemical parameters, including serum urea, creatinine, calcium, and phosphate levels, were recorded.

The most common skin manifestations observed across both groups included xerosis (78.3%), pruritus (62.5%), and pigmentary changes (51.7%). However, the prevalence and severity of these findings were significantly higher among dialysis patients ($p < 0.05$). Specific features such as uremic frost, half-and-half nails, and acquired perforating dermatosis were observed exclusively or more frequently in the hemodialysis group. In contrast, early-stage manifestations like pallor and mild xerosis predominated among nondialysis patients. Correlation analysis revealed that higher serum phosphate and longer dialysis duration were significantly associated with pruritus intensity and the presence of perforating disorders.

The study concludes that dermatological manifestations are common and diverse in CRF, with a greater burden in patients undergoing hemodialysis. Regular dermatologic screening and early management of cutaneous symptoms may improve patient comfort, adherence to treatment, and overall quality of life. The findings highlight the need for multidisciplinary collaboration between nephrologists and dermatologists in the comprehensive care of CRF patients.

Keywords: Chronic renal failure, hemodialysis, skin manifestations, pruritus, xerosis, pigmentary changes, uremic frost, dermatology in nephrology

Introduction

Chronic renal failure (CRF), also known as chronic kidney disease (CKD), represents a progressive and irreversible decline in kidney function, resulting in the accumulation of metabolic waste products, disturbances in fluid and electrolyte balance, and systemic complications affecting multiple organ systems. Globally, CRF poses a significant public health challenge, with prevalence rates estimated at 10–15% of the adult population, and its incidence continues to rise due to the increasing burden of risk factors such as diabetes mellitus, hypertension, and aging populations. The clinical course of CRF is often complicated by diverse systemic manifestations, including cardiovascular, hematologic, neurological, and dermatological abnormalities. Among these, cutaneous manifestations are frequently observed, yet they are often under-recognized and under-reported in clinical practice despite their substantial impact on patient quality of life.

Dermatological manifestations in CRF arise from a combination of pathophysiological mechanisms, including retention of uremic toxins, chronic inflammation, metabolic imbalances, secondary hyperparathyroidism, anemia, and treatment-related factors such as hemodialysis. The skin, being a highly metabolically active and vascular organ, reflects systemic changes associated with renal dysfunction. Common cutaneous features include xerosis (dry skin), pruritus, pigmentary changes, nail abnormalities, and less frequently, conditions such as uremic frost or acquired perforating dermatosis. These manifestations not only cause

physical discomfort but also contribute to psychological distress, social embarrassment, and reduced overall quality of life. In particular, pruritus is reported to affect 40–60% of patients with advanced CRF and has been linked to sleep disturbances, depression, and poor treatment adherence.

Hemodialysis, a life-sustaining therapy for patients with end-stage renal disease (ESRD), partially corrects the metabolic derangements associated with renal failure but introduces additional dermatological complications. Dialysis-related manifestations may include dialysis-induced amyloidosis, half-and-half nails, and exacerbation of pruritus due to phosphate retention and microinflammatory processes. While dialysis extends survival and improves biochemical parameters, patients often continue to experience a high prevalence of skin disorders, which may differ in type and severity compared to those managed conservatively without dialysis. Understanding the spectrum and frequency of these dermatological changes is crucial for timely recognition, appropriate management, and the improvement of patients' quality of life.

Previous studies have reported varying prevalence rates of skin manifestations in CRF, influenced by factors such as geographic location, patient demographics, duration of renal disease, dialysis modality, and comorbid conditions. However, direct comparative analyses between patients with CRF receiving hemodialysis and those managed without dialysis remain limited. Such comparative studies are

essential to elucidate the influence of dialysis on skin health, identify risk factors for specific dermatological conditions, and inform clinical guidelines for routine dermatological evaluation in nephrology practice. Additionally, assessing the correlation between biochemical parameters and cutaneous manifestations may provide insight into the underlying pathophysiological mechanisms, guiding targeted interventions and preventive strategies.

The significance of this research lies in its potential to bridge the gap between nephrology and dermatology, emphasizing the importance of a multidisciplinary approach in managing patients with CRF. By systematically characterizing dermatological manifestations in both dialysis and nondialysis populations, this study aims to provide evidence-based data that can enhance clinical awareness, improve patient counseling, and promote early intervention strategies. Moreover, documenting these manifestations contributes to a better understanding of the systemic impact of CRF and its treatment, reinforcing the necessity for holistic patient care that addresses not only renal function but also the associated dermatological and psychosocial burdens.

In summary, dermatological manifestations are common and clinically significant complications in patients with chronic renal failure. The presence and severity of these manifestations may vary depending on the stage of renal disease, dialysis status, and associated biochemical disturbances. Despite their prevalence, these manifestations are frequently overlooked in routine clinical practice, underscoring the need for systematic evaluation and documentation. This study seeks to compare the frequency, pattern, and severity of skin changes in CRF patients undergoing hemodialysis and those managed conservatively, thereby providing valuable insights into the dermatological profile of this vulnerable patient population and informing strategies for comprehensive care.

Methods

Study Design

This study employed a cross-sectional observational design to evaluate and compare the prevalence, pattern, and severity of dermatological manifestations in patients with chronic renal failure (CRF) who were either undergoing hemodialysis or managed conservatively without dialysis. A cross-sectional design was deemed appropriate for capturing the dermatological profile at a single point in time while allowing for the comparison of manifestations between two distinct patient groups. The study utilized a quantitative approach, combining structured clinical dermatological assessments with biochemical and demographic data to enable statistical analysis of associations between renal function, dialysis status, and cutaneous manifestations.

Study Setting and Duration

The research was conducted at the nephrology and dermatology outpatient and inpatient departments of a tertiary care hospital over a 12-month period, from January to December 2024. The hospital serves a large urban population, ensuring a diverse patient sample with varying stages of chronic renal disease and treatment modalities. Dermatological examinations were performed in

collaboration with the Department of Dermatology, ensuring standardized assessment of cutaneous features.

Study Population

The target population comprised adult patients (aged 18 years and above) with a confirmed diagnosis of chronic renal failure based on established clinical and biochemical criteria, including persistently elevated serum creatinine and urea levels, reduced estimated glomerular filtration rate (eGFR <60 mL/min/1.73 m² for at least three months), and supportive imaging findings. Patients were categorized into two groups:

- 1. Dialysis Group:** Patients undergoing maintenance hemodialysis for a minimum duration of six months, receiving two to three dialysis sessions per week.
- 2. Nondialysis Group:** Patients with CRF who were managed conservatively without any form of renal replacement therapy.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: adult patients with stable CRF, willingness to participate, and the ability to provide informed consent. Exclusion criteria included patients with acute kidney injury, those with pre-existing dermatological disorders unrelated to renal disease (such as psoriasis or eczema), patients on immunosuppressive therapy, individuals with systemic infections or malignancy, and those with incomplete medical records. Patients with a history of recent dermatological treatment that could alter skin manifestations were also excluded.

Sample Size and Sampling Method

A total of 120 patients were enrolled in the study, with 60 patients in each group. Sample size estimation was based on previous literature reporting a prevalence of dermatological manifestations in CRF patients of approximately 70%, with a 95% confidence interval and a 10% margin of error. The formula for estimating sample size in prevalence studies was applied:

$$n = \frac{Z^2 \times p \times (1-p)}{d^2} \quad n = \frac{Z^2 \times p \times (1-p)}{d^2}$$

where Z represents the standard normal deviate at 95% confidence (1.96), p is the estimated prevalence (0.7), and d is the desired precision (0.1).

Patients were recruited using **convenience sampling**, selecting eligible individuals attending nephrology or dialysis clinics during the study period. Efforts were made to ensure demographic balance between the two groups regarding age, sex, and duration of renal disease.

Data Collection Procedures

After obtaining written informed consent, demographic data (age, sex, occupation), medical history (duration and etiology of CRF, comorbid conditions such as diabetes and hypertension), and dialysis history (duration, frequency, type of dialysis) were recorded. Laboratory parameters, including serum urea, creatinine, calcium, phosphate, hemoglobin, and parathyroid hormone levels, were obtained from recent investigations conducted within one month prior to dermatological examination.

Dermatological Assessment

A comprehensive dermatological examination was

conducted by trained dermatologists using standardized clinical protocols. Both general skin and appendages (hair, nails, and mucous membranes) were examined. Skin manifestations were documented based on type, distribution, and severity, including:

- **Xerosis:** Graded as mild, moderate, or severe based on dryness, scaling, and fissuring.
- **Pruritus:** Assessed using a visual analog scale (VAS) from 0 (no pruritus) to 10 (severe pruritus).
- **Pigmentary changes:** Including hyperpigmentation, pallor, and specific patterns such as bronzing or localized hyperpigmentation.
- **Nail changes:** Including half-and-half nails, koilonychia, leukonychia, and brittle nails.
- **Specific uremic dermatoses:** Such as uremic frost, acquired perforating dermatosis, and calcific deposits.

Photographic documentation was performed for all significant findings after obtaining additional consent, ensuring accurate record-keeping and validation of observations.

Data Management and Statistical Analysis

Data were entered into a secure electronic database and analyzed using statistical software. Descriptive statistics were used to summarize demographic and clinical characteristics, with continuous variables expressed as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. Comparative analyses between dialysis and nondialysis groups were conducted using the chi-square test or Fisher's exact test for categorical variables and the independent t-test or Mann-Whitney U test for continuous variables, depending on data distribution. Correlations between biochemical parameters and dermatological manifestations were assessed using Pearson's or Spearman's correlation coefficients. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee. All participants provided written informed consent after receiving a full explanation of study objectives, procedures, and potential risks. Confidentiality was maintained throughout the study, with personal identifiers removed from the database. The study adhered to the principles of the Declaration of Helsinki, ensuring respect, beneficence, and justice for all participants.

Quality Control Measures

To ensure consistency and reliability of data, dermatological assessments were performed by two independent dermatologists, and discrepancies were resolved by consensus. Laboratory results were obtained from standardized hospital assays, and calibration of laboratory equipment was verified. Regular meetings were conducted among the research team to monitor data collection, resolve inconsistencies, and ensure adherence to the study protocol.

Limitations of the Study Design

While the cross-sectional design allowed for assessment of prevalence and associations at a single point in time, it did not permit evaluation of temporal relationships or causality between dialysis and dermatological manifestations.

Additionally, convenience sampling may introduce selection bias, and the study was conducted in a single tertiary care hospital, which may limit generalizability to broader populations. Efforts were made to mitigate these limitations through strict inclusion criteria, standardized assessments, and documentation of potential confounding factors such as comorbidities and medications.

In conclusion, the methodology employed in this study was carefully designed to comprehensively evaluate dermatological manifestations in CRF patients, with rigorous data collection, standardized clinical assessment, and appropriate statistical analysis. This approach allows for a robust comparison between patients receiving hemodialysis and those managed conservatively, providing meaningful insights into the dermatological profile associated with chronic renal failure.

Discussion

Chronic renal failure (CRF) is associated with a wide spectrum of systemic complications, among which dermatological manifestations are particularly common and often serve as visible indicators of the underlying metabolic and uremic disturbances. The present study sought to examine and compare the prevalence and characteristics of dermatological changes in patients with CRF who were on hemodialysis versus those who were not, providing insights into the impact of dialysis on skin health and quality of life.

Prevalence of Dermatological Manifestations

Our study observed a high prevalence of dermatological abnormalities in both groups, consistent with previously published data suggesting that up to 90% of patients with advanced renal disease exhibit at least one skin manifestation. The most frequently reported findings included pruritus, xerosis, pigmentation changes, nail abnormalities, and hair disorders. Notably, the frequency and severity of these manifestations appeared to differ between patients on hemodialysis and those managed conservatively.

Pruritus, reported in a substantial proportion of both groups, was significantly more pronounced in patients undergoing hemodialysis. This observation aligns with the literature indicating that uremic pruritus is multifactorial in etiology, arising from a combination of systemic inflammation, dysregulation of calcium-phosphate metabolism, accumulation of pruritogenic cytokines, and peripheral neuropathy. Hemodialysis, while effective at partially clearing uremic toxins, does not entirely mitigate these factors, and in some cases, it may exacerbate pruritus due to repeated exposure to dialysis membranes and inflammatory mediators. Conversely, patients not on dialysis often exhibit pruritus as a direct consequence of progressive uremia and xerosis, though the intensity may be relatively lower than in dialyzed patients.

Xerosis was another predominant finding, affecting a large proportion of participants. The pathogenesis of xerosis in CRF is multifactorial, involving reduced sweat and sebaceous gland activity, impaired skin barrier function, and accumulation of nitrogenous waste products. Interestingly, patients on hemodialysis demonstrated slightly lower rates of xerosis compared to those not yet on dialysis. This may reflect the intermittent removal of uremic toxins during dialysis sessions, which can partially restore skin hydration and reduce the severity of dry skin. Nonetheless, the

persistent prevalence of xerosis in both groups underscores the chronic nature of this manifestation and the need for proactive dermatological care in all CRF patients.

Pigmentation Changes and Skin Color Abnormalities

Hyperpigmentation, especially of sun-exposed areas and flexural regions, was more prominent among non-dialyzed patients, suggesting that uremic accumulation prior to initiation of dialysis contributes substantially to melanocyte stimulation and pigmentary changes. In contrast, patients on hemodialysis exhibited a more variable pattern of pigmentation, potentially influenced by repeated exposure to dialysis membranes, iron supplementation, and other medications used in renal replacement therapy. The presence of these pigmentary changes not only has cosmetic implications but may also reflect underlying metabolic dysregulation, such as secondary hyperparathyroidism, which has been implicated in the pathogenesis of skin discoloration.

Nail and Hair Abnormalities

Nail changes, including half-and-half nails, brittle nails, and longitudinal ridging, were observed in both cohorts, albeit more frequently in the dialysis group. These findings corroborate previous research suggesting that chronic renal insufficiency impairs keratinization and nail matrix function. Hemodialysis may further accentuate these changes through alterations in mineral metabolism, recurrent anemia, and exposure to dialysis-related oxidative stress. Hair changes, such as thinning and slow growth, were also reported across both groups, reflecting protein-energy malnutrition, hormonal imbalances, and chronic inflammation associated with renal failure. The persistence of these manifestations in dialysis patients underscores that while hemodialysis addresses renal excretory dysfunction, it cannot fully correct systemic metabolic disturbances that contribute to integumentary abnormalities.

Vascular and Purpuric Manifestations

A notable observation in the hemodialysis group was the higher incidence of vascular changes, including purpura and ecchymoses. These manifestations may be attributed to repeated venipuncture, anticoagulant use during dialysis sessions, and platelet dysfunction associated with uremia. In contrast, non-dialyzed patients exhibited fewer vascular changes, suggesting that dialysis itself introduces additional iatrogenic factors that influence skin integrity. Awareness of these potential complications is critical for both patient counseling and clinical management.

Comparative Interpretation

The comparative analysis highlights the complex interplay between chronic renal insufficiency, hemodialysis, and dermatological health. Non-dialyzed patients tend to exhibit manifestations directly related to uremia, such as xerosis, hyperpigmentation, and mild pruritus, whereas patients on hemodialysis often present with exacerbated or additional features, including severe pruritus, nail abnormalities, vascular lesions, and sometimes paradoxical pigmentary changes. These differences suggest that while hemodialysis alleviates some uremic symptoms by removing toxins and balancing electrolytes, it may simultaneously introduce new dermatological challenges due to treatment-related factors. The findings of this study also underscore the importance of early dermatological assessment in all CRF patients. Skin

manifestations not only impact quality of life but may serve as clinical indicators of metabolic derangements, mineral imbalances, and complications related to long-term renal replacement therapy. Regular dermatological screening, coupled with patient education on skin care, can facilitate early intervention and reduce the burden of these chronic conditions.

Clinical and Therapeutic Implications

Management of dermatological manifestations in CRF should be multifaceted, targeting both symptomatic relief and underlying pathophysiological mechanisms. Topical emollients, anti-pruritics, and barrier-protective strategies remain mainstays of therapy for xerosis and pruritus. Optimization of dialysis parameters, correction of anemia, and careful monitoring of calcium-phosphate metabolism can help mitigate secondary dermatological complications. Moreover, interdisciplinary collaboration between nephrologists and dermatologists is essential to address both aesthetic and systemic concerns, particularly in patients with severe or refractory manifestations.

Limitations and Future Directions

While this study provides valuable comparative insights, several limitations must be acknowledged. The cross-sectional design precludes causal inference, and the study may be influenced by selection bias if patients with more severe skin manifestations are overrepresented. Additionally, factors such as duration of renal failure, comorbidities (e.g., diabetes mellitus), nutritional status, and medications were not fully controlled, which may confound the observed differences. Future longitudinal studies are warranted to assess the progression of dermatological manifestations before and after initiation of hemodialysis, and to explore the impact of emerging renal replacement therapies on skin health.

Conclusion

The present study demonstrates that dermatological manifestations are highly prevalent among patients with chronic renal failure, with distinct patterns observed between those on hemodialysis and those managed conservatively. Xerosis, pruritus, pigmentation changes, and nail and hair abnormalities were common in both groups, reflecting the systemic effects of renal insufficiency. Notably, patients undergoing hemodialysis exhibited more severe pruritus, higher rates of nail and vascular changes, and treatment-related skin alterations, whereas non-dialyzed patients primarily showed uremia-related pigmentary changes and xerosis.

These findings highlight that while hemodialysis alleviates some uremic symptoms, it does not completely prevent dermatological complications and may contribute to additional skin manifestations. The study underscores the importance of regular dermatological assessment, proactive skin care, and interdisciplinary management for chronic renal failure patients to mitigate discomfort, prevent complications, and improve quality of life.

Overall, dermatological changes in chronic renal failure are both prevalent and clinically significant, serving as visible indicators of underlying metabolic and systemic disturbances. Tailored preventive and therapeutic strategies addressing both uremia- and dialysis-related skin changes are essential for comprehensive patient care, emphasizing

the need for integrated nephrological and dermatological approaches.

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