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Prevalence and Clinical Profile of Corticosteroid-Induced Hyperglycaemia and Immunosuppression in Hospitalised Adults: A Multi Arm Retrospective Cross-Sectional Study from Tertiary Care Hospitals

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Abstract

Background: Corticosteroids are widely used in hospitalised adults for inflammatory, autoimmune, respiratory, neurological, and infectious conditions. While their short-term benefits are well recognised, systemic corticosteroids are associated with significant metabolic and immunological adverse effects, notably hyperglycaemia and immunosuppression. These complications gained particular prominence during the COVID-19 pandemic, when widespread steroid use, combined with oxygen therapy and pre-existing diabetes, was linked to a surge in opportunistic infections such as mucormycosis and invasive aspergillosis. Data from Indian tertiary care settings evaluating the combined burden of corticosteroid-induced hyperglycaemia and immunosuppression remain limited.

Objectives: To determine the prevalence of corticosteroid-induced hyperglycaemia and immunosuppression among hospitalised adults, describe their clinical profile, identify associated complications including infections and electrolyte disturbances, and evaluate outcomes in a tertiary care hospital setting.

Methods: This multi-arm retrospective cross-sectional study was conducted in tertiary care hospitals over a 12-month period. Medical records of 164 hospitalised adults (≥18 years) who received systemic corticosteroids for ≥5 days were analysed. Patients were stratified into three arms: (1) known diabetics, (2) newly detected hyperglycaemia following steroid initiation, and (3) normoglycaemic patients. Data collected included demographic variables, indication, type and dose of corticosteroids, glycaemic parameters, markers of immunosuppression, infectious complications, electrolyte abnormalities, neuromuscular, neuropsychiatric, and cardiovascular effects. Outcomes were analysed using descriptive statistics.

Results: Out of 164 patients, corticosteroid-induced hyperglycaemia was observed in 98 patients (59.8%). Newly detected hyperglycaemia occurred in 46 patients (28.0%), while worsening glycaemic control in

known diabetics was seen in 52 patients (31.7%). Immunosuppression-related infections were documented in 41 patients (25.0%), with mucormycosis identified in 9 patients (5.5%) and invasive aspergillosis in 7 patients (4.3%), predominantly among diabetics and post-COVID patients receiving oxygen therapy. Febrile neutropenia was noted in 6 patients (3.7%). Additional adverse effects included hypernatremia (18.9%), proximal neuromuscular weakness (14.6%), neuropsychiatric manifestations (11.0%), and cardiovascular complications such as hypertension and arrhythmias (16.5%). Mortality was higher among patients with combined hyperglycaemia and severe infections.

Conclusion: Corticosteroid-induced hyperglycaemia and immunosuppression are common and clinically significant among hospitalised adults, particularly in patients with diabetes and those treated during the COVID-19 pandemic. Vigilant monitoring, early identification of metabolic and infectious complications, and judicious tapering of steroids are essential to prevent adverse outcomes, including life-threatening opportunistic infections and adrenal insufficiency.

Keywords: Corticosteroids, Hyperglycaemia, Immunosuppression, Diabetes Mellitus, Mucormycosis, Invasive Aspergillosis, COVID-19, Hospitalised Adults

Introduction

Corticosteroids are among the most commonly prescribed pharmacological agents in hospitalised patients due to their potent anti-inflammatory, immunosuppressive, and anti-allergic properties. They are routinely used in a wide range of clinical conditions including bronchial asthma, chronic obstructive pulmonary disease (COPD), autoimmune disorders, neurological illnesses, malignancies, septic shock, and post-transplant care. Despite their undeniable therapeutic benefits, systemic corticosteroids are associated with a broad spectrum of adverse metabolic, endocrine, and immunological effects, which can significantly impact patient morbidity and mortality.

One of the most frequent and clinically relevant complications of corticosteroid therapy is hyperglycaemia. Corticosteroids induce insulin resistance, enhance hepatic gluconeogenesis, reduce peripheral glucose uptake, and impair pancreatic β-cell function. These effects can lead to new-onset hyperglycaemia in previously non-diabetic individuals or exacerbate glycaemic control in patients with pre-existing diabetes mellitus. Steroid-induced hyperglycaemia has been associated with prolonged hospital stay, increased risk of infections, poor wound healing, and adverse cardiovascular outcomes. Importantly, stress hyperglycaemia in hospitalised patients is now recognised as an independent predictor of poor prognosis.

Equally significant is the immunosuppressive effect of corticosteroids, which occurs through multiple mechanisms including inhibition of cytokine production, suppression of T-cell and macrophage function, impaired neutrophil migration, and reduced humoral immunity. While these effects are beneficial in controlling inflammatory and autoimmune diseases, they predispose patients to a wide range of infections, particularly opportunistic fungal and bacterial infections. Immunosuppression is further amplified in patients with diabetes mellitus, malnutrition, malignancy, and those receiving prolonged or high-dose steroid therapy.

The COVID-19 pandemic brought renewed attention to the adverse effects of corticosteroids. Although systemic steroids such as dexamethasone significantly reduced mortality in patients with severe COVID-19 requiring oxygen therapy, their widespread and sometimes indiscriminate use led to a surge in secondary infections. Notably, a marked increase in COVID-19–associated mucormycosis (CAM) was observed, especially in patients with uncontrolled diabetes who received steroids and oxygen therapy via

face masks or humidified systems. The triad of hyperglycaemia, steroid-induced immunosuppression, and hypoxia created an ideal milieu for invasive fungal infections. In addition to mucormycosis, invasive aspergillosis emerged as a serious complication in immunocompromised patients, often presenting as febrile neutropenia with high mortality rates.

Beyond hyperglycaemia and infections, corticosteroids are associated with several other systemic adverse effects. Electrolyte disturbances such as hypernatremia occur due to mineralocorticoid effects leading to sodium retention. Neuromuscular complications, including steroid-induced myopathy and proximal muscle weakness, can impair mobility and prolong rehabilitation. Neuropsychiatric manifestations such as mood disturbances, psychosis, insomnia, and cognitive impairment are well documented, particularly with high-dose therapy. Cardiovascular effects, including hypertension, arrhythmias, fluid retention, and worsening heart failure, further contribute to the overall risk profile of steroid therapy.

Despite the high prevalence and clinical significance of these complications, data integrating corticosteroid-induced hyperglycaemia and immunosuppression within a single study framework remain limited, particularly from tertiary care hospitals in developing countries. Understanding the combined metabolic and immunological burden of corticosteroid therapy is essential for improving risk stratification, monitoring protocols, and patient outcomes.

Therefore, this study was undertaken to assess the prevalence and clinical profile of corticosteroid-induced hyperglycaemia and immunosuppression in hospitalised adults, evaluate associated infectious and non-infectious complications, and highlight the importance of appropriate steroid use, monitoring, and gradual withdrawal to prevent life-threatening consequences such as adrenal insufficiency and Addisonian crisis.

Materials and Methods

Study Design and Setting: This was a multi-arm retrospective cross-sectional study conducted at tertiary care teaching hospitals over a period of 12 months. The study involved review of hospital medical records from departments including General Medicine, Pulmonology, Intensive Care, Neurology, and Infectious Diseases. Institutional ethics committee approval was obtained prior to initiation of the study, and patient confidentiality was strictly maintained. As this was a retrospective record-based study, informed consent was waived.

Study Population and Sample Size: A total of 164 hospitalised adult patients who received systemic corticosteroid therapy during their hospital stay were included in the study.

Inclusion Criteria

1. Age ≥18 years
2. Hospitalised patients who received systemic corticosteroids (oral or intravenous) for a duration of ≥5 days
3. Availability of complete medical records including blood glucose values and infection-related data

Exclusion Criteria

1. Patients with type 1 diabetes mellitus
2. Patients with known adrenal disorders
3. Patients on long-term steroid therapy prior to admission (>3 months)
4. Pregnant and lactating women
5. Incomplete or missing medical records

Study Arms (Patient Stratification)

Patients were categorised into three arms based on glycaemic status:

Arm A (Known Diabetics): Patients with pre-existing diabetes mellitus prior to steroid initiation

Arm B (Steroid-Induced Hyperglycaemia): Patients without prior diabetes who developed hyperglycaemia following corticosteroid therapy

Arm C (Normoglycaemic): Patients who maintained normal glycaemic values throughout steroid therapy

Operational Definitions

Hyperglycaemia:

1. Fasting plasma glucose ≥126 mg/dL and/or
2. Random plasma glucose ≥200 mg/dL on two or more occasions after initiation of corticosteroids

Immunosuppression:

Defined by occurrence of opportunistic infections, persistent leukopenia/neutropenia, or need for antifungal/antiviral therapy during hospitalisation

Febrile Neutropenia:

Absolute neutrophil count <1500 cells/mm³ with fever ≥38°C

High-Dose Steroid Therapy:

Equivalent of ≥40 mg/day of prednisolone

Data Collection

Data were extracted from patient case files, electronic medical records, laboratory reports, and discharge summaries using a structured proforma. The following variables were recorded:

1. Demographic Data: Age, sex
2. Clinical Data: Indication for steroid therapy, duration of hospital stay, ICU admission
3. Steroid Details: Type (dexamethasone, methylprednisolone, prednisolone, hydrocortisone), dose, route, and duration
4. Metabolic Parameters: Fasting and random blood glucose levels, HbA1c (where available), serum sodium levels

Immunological and Infectious Profile: Total leukocyte count, absolute neutrophil count, documented bacterial and fungal infections (mucormycosis, invasive aspergillosis)

Systemic Complications:

1. Electrolyte disturbances (hypernatremia)
2. Neuromuscular weakness
3. Neuropsychiatric manifestations
4. Cardiovascular complications (hypertension, arrhythmias)

Outcomes: Length of hospital stay, need for antifungal therapy, mortality

COVID-19 Subgroup Analysis

Patients admitted with moderate to severe COVID-19 infection and treated with systemic corticosteroids and oxygen therapy were analysed as a subgroup. Special emphasis was placed on incidence of mucorm-

ycosis and other opportunistic infections in this cohort.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using standard statistical software. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparative analysis between groups was performed using chi-square test for categorical variables and Student's t-test for continuous variables. A p-value <0.05 was considered statistically significant.

Results

Baseline Demographic and Clinical Characteristics

A total of 164 hospitalised adult patients who received systemic corticosteroids were included in the final analysis. The mean age of the study population was 52.6 ± 14.8 years (range: 19–82 years). Of these, 98 patients (59.8%) were males and 66 patients (40.2%) were females, with a male-to-female ratio of 1.48:1

The most common indications for corticosteroid therapy were respiratory illnesses including COVID-19 pneumonia, COPD, and severe asthma exacerbations (42.1%), followed by neurological disorders such as autoimmune encephalitis and spinal cord diseases (18.3%), infectious and inflammatory conditions (16.5%), malignancy-related indications (12.2%), and other autoimmune disorders (10.9%).

Steroid Usage Profile

The commonly prescribed corticosteroids included:

1. Dexamethasone in 72 patients (43.9%)
2. Methylprednisolone in 56 patients (34.1%)
3. Prednisolone in 24 patients (14.6%)

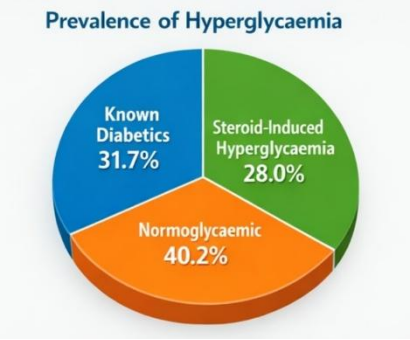
Hydrocortisone in 12 patients (7.4%)

High-dose steroid therapy (≥40 mg prednisolone equivalent/day) was administered to 94 patients (57.3%), while the remaining 70 patients (42.7%) received moderate-dose therapy. The mean duration of steroid therapy was 9.4 ± 3.2 days.

Prevalence of Corticosteroid-Induced Hyperglycaemia

Out of 164 patients, 98 patients (59.8%) developed hyperglycaemia during hospitalisation.

1. Arm A (Known Diabetics): 52 patients (31.7%)
2. Arm B (Steroid-Induced Hyperglycaemia): 46 patients (28.0%)
3. Arm C (Normoglycaemic): 66 patients (40.2%)



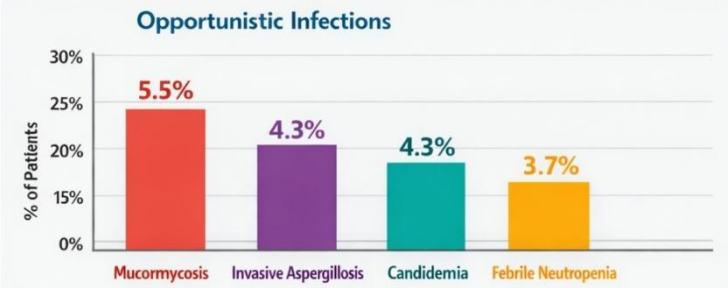
Among patients with newly detected hyperglycaemia (Arm B), the mean random blood glucose level was 268.4 ± 42.6 mg/dL, while worsening glycaemic control in known diabetics (Arm A) was evidenced by a mean increase in insulin requirement of 38.5% during hospital stay. Hyperglycaemia was significantly more common in patients receiving high-dose steroids compared to moderate-dose therapy ($p < 0.01$).

Immunosuppression and Infectious Complications

Evidence of steroid-induced immunosuppression, manifesting as opportunistic or severe infections, was observed in 41 patients (25.0%).

Bacterial infections: 19 patients (11.6%)

Fungal infections: 23 patients (14.0%)



Among fungal infections:

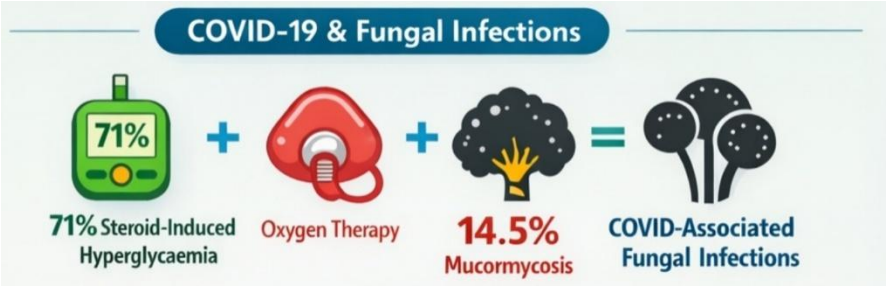
1. Mucormycosis was diagnosed in 9 patients (5.5%)
2. Invasive aspergillosis in 7 patients (4.3%)
3. Candidemia in 7 patients (4.3%)

A significant proportion of patients with mucormycosis (77.8%) had pre-existing diabetes and a history of recent COVID-19 infection. All mucormycosis patients had received systemic corticosteroids and oxygen therapy via face masks or humidified oxygen delivery systems.

COVID-19–Associated Findings

Out of the total cohort, 62 patients (37.8%) were admitted with moderate to severe COVID-19 pneumonia. Among these:

1. Steroid-induced hyperglycaemia was observed in 44 patients (71.0%)
2. Secondary fungal infections occurred in 15 patients (24.2%)
3. COVID-19–associated mucormycosis was seen in 9 patients (14.5%)

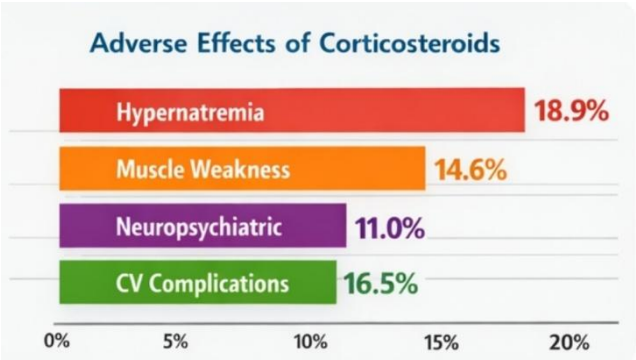


The combination of uncontrolled hyperglycaemia, prolonged steroid therapy, and hypoxia was strongly associated with development of opportunistic fungal infections.

Febrile Neutropenia and Invasive Aspergillosis

Febrile neutropenia was documented in 6 patients (3.7%), all of whom were immunocompromised due to high-dose steroid therapy, malignancy, or post-COVID status. Among these patients, invasive aspergillosis was confirmed in 5 cases, presenting with persistent fever, respiratory distress, and radiological evidence of fungal pneumonia.

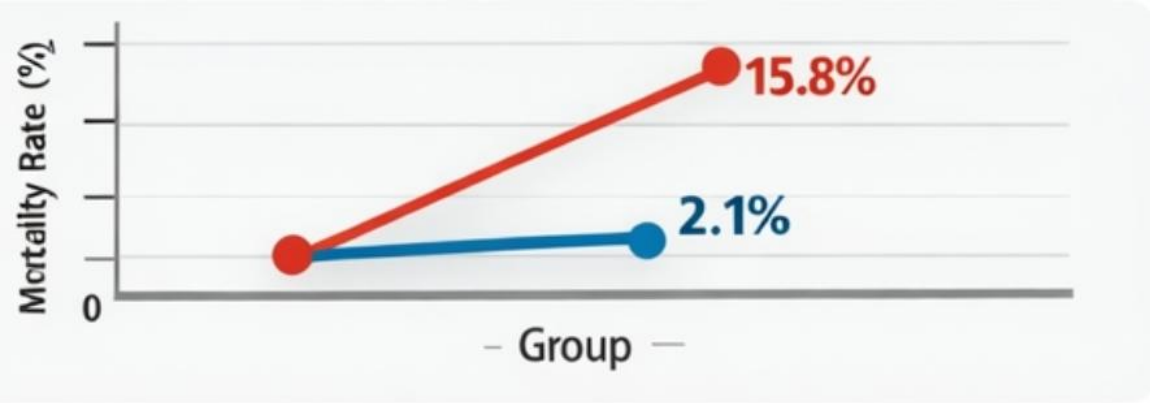
Other Systemic Adverse Effects



Additional steroid-related complications included:
Hypernatremia: 31 patients (18.9%)
Proximal neuromuscular weakness (steroid myopathy): 24 patients (14.6%)
Neuropsychiatric manifestations (insomnia, mood disturbances, psychosis): 18 patients (11.0%)
Cardiovascular complications (new-onset hypertension, arrhythmias): 27 patients (16.5%)
These adverse effects were more frequent among patients receiving high-dose and prolonged steroid therapy.

Clinical Outcomes

The mean duration of hospital stay was significantly longer in patients with hyperglycaemia and infections (12.8 ± 4.6 days) compared to normoglycaemic patients (8.2 ± 3.1 days, p <0.001). ICU admission was required in 29 patients (17.7%).



Overall in-hospital mortality was 8.5% (14 patients) and was highest among patients with combined hyperglycaemia and invasive fungal infections.

Discussion

This multi-arm retrospective cross-sectional study highlights the substantial burden of corticosteroid-induced hyperglycaemia and immunosuppression among hospitalised adults in tertiary care settings. In our cohort of 164 patients, nearly 60% developed hyperglycaemia, reaffirming that disturbances in glucose metabolism are among the most common and clinically relevant adverse effects of systemic corticosteroid therapy.

The prevalence of hyperglycaemia observed in this study is comparable to previously published literature, where steroid-induced hyperglycaemia has been reported in 40–70% of hospitalised patients receiving systemic corticosteroids [1,2]. Importantly, 28% of our patients developed new-onset hyperglycaemia, underscoring that steroid-induced dysglycaemia is not limited to known diabetics. Corticosteroids promote insulin resistance, enhance hepatic gluconeogenesis, and impair peripheral glucose uptake, mechanisms that are particularly pronounced with high-dose and prolonged therapy [3]. In our study, high-dose steroid use showed a statistically significant association with hyperglycaemia, consistent with existing evidence [4].

Diabetes mellitus emerged as a critical risk factor for adverse outcomes. Patients with pre-existing diabetes not only demonstrated worsening glycaemic control but also exhibited a higher susceptibility to infections. Chronic hyperglycaemia impairs neutrophil chemotaxis, phagocytosis, and cell-mediated immunity, thereby compounding the immunosuppressive effects of corticosteroids [5]. This synergistic impairment likely explains the increased frequency of opportunistic infections seen in diabetic patients within our cohort.

A key finding of this study is the high prevalence of steroid-associated immunosuppression and opportunistic infections (25%), particularly invasive fungal infections. The COVID-19 pandemic provided a unique clinical context in which the consequences of widespread steroid use became evident. Among post-COVID patients in our study, the triad of systemic corticosteroid therapy, uncontrolled hyperglycaemia, and oxygen therapy via face masks or humidified systems was strongly associated with the development of mucormycosis. This observation aligns with the surge of COVID-19–associated mucormycosis reported globally, especially from India, during the pandemic [6,7].

Mucormycosis was predominantly observed in patients with diabetes and recent COVID-19 infection, supporting the hypothesis that steroid-induced immunosuppression, coupled with hyperglycaemia and hypoxic tissue environments, creates an ideal milieu for Mucorales growth [8]. In addition, contamination of humidifiers and prolonged use of oxygen delivery devices may further increase exposure to fungal spores.

The occurrence of invasive aspergillosis and febrile neutropenia in our study highlights another critical consequence of steroid-induced immunosuppression. Corticosteroids impair macrophage and T-cell function and alter neutrophil kinetics, predisposing patients to invasive aspergillosis, particularly in those with malignancy, prolonged ICU stay, or post-viral lung damage [9]. Febrile neutropenia, though less frequent, was associated with significant morbidity and reflects profound immune dysregulation in high-risk patients.

Beyond metabolic and infectious complications, systemic corticosteroids were associated with several other clinically relevant adverse effects. Hypernatremia, observed in nearly one-fifth of patients, is

attributable to the mineralocorticoid effects of steroids leading to sodium retention and free water loss [10]. Steroid-induced myopathy, manifesting as proximal muscle weakness, adversely affected patient mobility and prolonged hospital stay. Neuropsychiatric manifestations and cardiovascular complications such as hypertension and arrhythmias further contributed to overall morbidity, consistent with earlier studies [11,12].

An important clinical implication highlighted by this study is the necessity of appropriate steroid tapering. Abrupt cessation of systemic corticosteroids can precipitate acute adrenal insufficiency (Addisonian crisis) due to suppression of the hypothalamic–pituitary–adrenal axis. Gradual dose reduction is essential, particularly in patients receiving high-dose or prolonged therapy, to allow recovery of endogenous cortisol production [13].

Overall, patients with combined hyperglycaemia and immunosuppression experienced longer hospital stays, higher ICU admission rates, and increased mortality, emphasising the need for early recognition and proactive management.

Conclusion

Corticosteroid-induced hyperglycaemia and immunosuppression are highly prevalent and clinically significant among hospitalised adults. More than half of patients receiving systemic corticosteroids develop hyperglycaemia, with a substantial proportion experiencing new-onset dysglycaemia. Diabetes mellitus significantly increases susceptibility to infections, particularly opportunistic fungal infections.

The COVID-19 pandemic has underscored the potential dangers of indiscriminate steroid use, with a clear association between steroid therapy, hyperglycaemia, oxygen delivery systems, and invasive fungal infections such as mucormycosis and aspergillosis. In addition, corticosteroids contribute to electrolyte disturbances, neuromuscular weakness, neuropsychiatric symptoms, and cardiovascular complications, all of which increase patient morbidity.

Judicious use of corticosteroids, regular monitoring of blood glucose and electrolytes, early detection of infections, and gradual tapering rather than abrupt withdrawal are essential to minimise adverse outcomes. A multidisciplinary approach involving physicians, endocrinologists, and infectious disease specialists is crucial for optimising patient care. Future prospective studies are needed to develop standardised protocols for prevention and management of steroid-induced metabolic and immunological complications.

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