



# An Old Theme and New Technology: Marked Glucocorticoid-Induced Hyperglycemia in a Hospitalized Patient Uncovered Retrospectively by Her Flash Glucose Monitoring

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## Abstract

**Background** Glucocorticoid-induced hyperglycemia is a problem-facing endocrinologists and internal medicine specialists in hospital wards.

**Case History** A 63-year-old woman with type 2 diabetes was admitted to the hospital with acute exacerbation of chronic obstructive airway disease. She was treated with a short course of intravenous hydrocortisone followed by oral prednisolone. On discharge, she attended her regular diabetes consultation. Throughout the period, she had her flash glucose monitoring (FGM) sensor in place, and she was monitoring her blood glucose regularly. As part of her diabetes clinic routine, the meter data uploaded and ambulatory glucose profiles were examined. These revealed three distinctly different blood glucose levels before, during, and after glucocorticoid therapy. Glucocorticoid therapy resulted in a marked rise in blood glucose that lasted for a further week before it returned to the pre-treatment levels. This old phenomenon has yet to be demonstrated using the new FGM technology.

**Conclusions** The story (1) asserts the significant impact of glucocorticoid therapy on glycemic control, (2) demonstrates the prolonged impact on glycemic control following discontinuation of glucocorticoids, (3) suggests a lack of adequate monitoring and timely recognition of hyperglycemia in the hospital, and poor management glucocorticoid-induced hyperglycemia either due to failure of conventional monitoring methods or a degree of complacency to appreciate its magnitude.

## Keywords

- ▶ glucocorticoid
- ▶ hospitalized patients
- ▶ hyperglycemia
- ▶ Glucocorticoid-induced hyperglycemia
- ▶ continuous glucose monitoring

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## Introduction

Glucocorticoids (GCs) were discovered in the 1940s as extracts of the adrenal cortex and this was followed by the isolation of adrenocorticotropic hormone from pituitary gland extracts.<sup>1</sup> GCs derive their name from early observations that these hormones were involved in glucose metabolism. GC-induced hyperglycemia is a common problem faced by endocrinologists and internal medicine specialists in hospital wards and outpatient clinics.<sup>2-5</sup> GCs can worsen diabetes and may even cause hyperglycemia and diabetes de novo.<sup>2-5</sup>

Postprandial hyperglycemia is more markedly seen than fasting hyperglycemia, even in cases of GC replacement therapy.<sup>6</sup> Patients at risk for GC-induced diabetes should undergo blood glucose (BG) monitoring and be screened for pre-existing undiagnosed diabetes. Several good clinical practice.<sup>7-11</sup> and expert opinions.<sup>12</sup> are available for avoidance, detection, and management of GC-induced hyperglycemia. Conventionally, sulphonylureas are the mainstays of oral treatment due to their rapid onset of action. However, evidence exists for several other agents, including metformin and dipeptidyl peptidase-IV inhibitors.<sup>7-12</sup> Failure to respond to oral hypoglycemic agents suggests the need for the initiation of insulin.<sup>7-12</sup> However, close monitoring is crucial to the timely detection of GC-hyperglycemia.

Flash glucose monitoring (FGM) is expanding and has been used in several circumstances with various clinical and ethnic implications.<sup>13,14</sup> We present a visual vignette where the new technology of FGM gave insight into hyperglycemia's magnitude and time-related to using GCs in hospitalized patients.

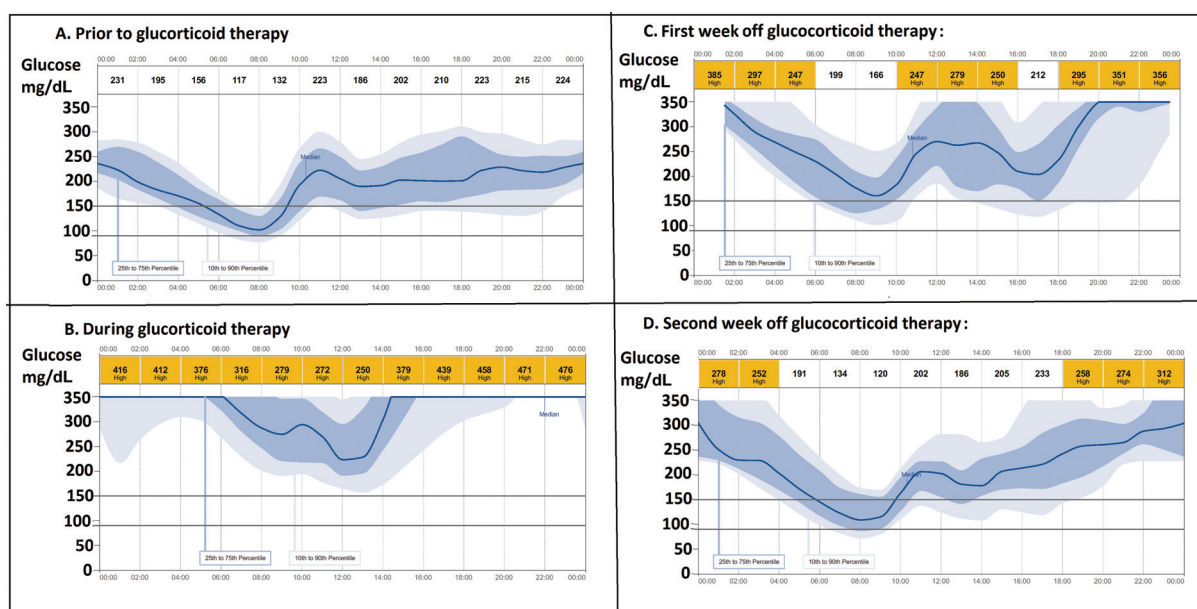
## Case History

A 63-year-old woman (body mass index: 38 kg/m<sup>2</sup>) with type 2 diabetes was admitted to the hospital with acute exacerbation of chronic obstructive airway disease due to interstitial emphysema. Her most recent hemoglobin A1c was 6.9%. She was being treated with insulin degludec 40 units daily, insulin aspart 10 to 12 units three times daily (TID), linagliptin 5 mg/day, and repaglinide 2 mg TID previously. Past medical history includes coronary artery disease, congestive heart failure, previous stroke resulting in poor mobility and almost wheel-chair bound status, chronic kidney disease, hyperlipidemia, and morbid obesity, vitamin D deficiency. The pulmonology services recommended treating her with intravenous (IV) methylprednisolone 40 mg IV 8 hourly for 1 day, followed by tapered oral prednisolone (starting at 40 mg daily). She received GCs for 10 days.

On discharge from the hospital, she attended her regular diabetes consultation after 1 week. Throughout the hospitalization period, she had her FGM sensor in place, and she was monitoring her BG regularly. As part of her diabetes clinic routine, the meter data were uploaded, and the ambulatory glucose profile (AGP) was examined. These AGPs revealed three distinct patterns illustrating her glucose profiles before, during, and after the GC therapy (→Fig. 1A–D). The calculated AGP metrics for the corresponding periods are shown in →Table 1. GC therapy resulted in a marked and prolonged rise in BG that lasted for a further week before it returned to the pre-treatment levels.

**Discussion**

GCs are powerful and effective anti-inflammatory and immunosuppressive drugs.<sup>2-4,12</sup> They are used extensively to treat different diseases, even though their side effects, such as hypertension, osteoporosis, and, in particular, diabetes, are well known. They can exacerbate hyperglycemia in patients with diabetes mellitus or facilitate the development of metabolic disease in apparently healthy subjects<sup>3-5,8,14</sup>



**Fig. 1** Ambulatory glucose profiles depicting blood glucose monitoring patterns before (A), during (B), and both 1 week (C), and 2 weeks (D) after glucocorticoid therapy.

**Table 1** Selected AGP parameters extracted for the time periods before, during, and after GC therapy

Time point	Duration (days)	Daily average glucose (mg/dL)	Estimated HbA1c % (mmol/mmol)	Range achievements (%)		
				Above	In-range	Below
Before GC therapy	14	191	8.3 (67)	71%	25%	4%
During GC therapy	10	376	14.7 (137)	97%	3%	0%
After GC therapy—week 1	7	264	10.8 (95)	86%	14%	0%
After GC therapy—week 2	8	216	9.2 (77)	76%	19%	5%

Abbreviations: AGP, ambulatory glucose profiles; GC, glucocorticoids; HbA1c, hemoglobin A1c.

GC-induced diabetes is an independent risk factor for other complications associated with GCs use.<sup>3–5,8,14</sup> In this case, the AGP at different times in relation to GC therapy visualizes the marked and persistent GC-induced hyperglycemia.

A detailed discussion of GC-induced diabetes is beyond the scope of this short contribution. However, a recent in-depth review concluded that it is a harmful and underestimated problem when the therapeutic program is not correct and well-planned.<sup>3–5,8,12</sup> Screening or more stringent monitoring must invariably be established before starting with corticosteroids. Moreover, the antihyperglycemic therapy should be personalized based on the severity of hyperglycemia, the type of steroid used, and the patient's comorbidities. All oral glucose-lowering drugs can be used, but sulphonylureas and insulin are the most studied drugs. Insulin is the medication recommended for severe hyperglycemia, for patients with pre-existing diabetes, or for patients with to undergo prolonged therapy over time.

However, there are no studies that have examined the effect of the frequency of bedside BG monitoring on the incidence of hyper- or hypoglycemia in the hospital setting. The frequency and timing of bedside BG monitoring can be individualized. However, monitoring is typically performed before meals and at bedtime in people who are eating, every 4 to 6 hours in people who are nothing by mouth or receiving continuous enteral feeding, and every 1 to 2 hours for people on continuous IV insulin or those who are critically ill.<sup>11</sup> Some bedside BG monitoring is indicated in individuals without known diabetes but receiving treatments known to be associated with hyperglycemia (e.g., GCs such as our patients).<sup>3–5,7–11</sup> The documented infrequent monitoring in her care is an omission, the seriousness of which is supported by the retrospectively uncovered marked and persistent hyperglycemia. A recent survey of physicians in the Netherlands concluded that while physicians screen for GC-induced hyperglycemia, their treatment is low or delayed.<sup>15</sup>

## Conclusions

Although FGM is not currently used in hospitals, the moral of the story is that the downloaded FGM data has by chance uncovered several findings. It asserted the significant impact of GC therapy on glycemic control, demonstrated the prolonged impact on glycemic control following discontinuation of GCs, and revealed the inadequate monitoring and timely

recognition of hyperglycemia in the hospital. It also suggested poor management of GC-induced hyperglycemia, indicated by the infrequency of conventional glucose monitoring and lack of action. This could reflect a degree of complacency or inability to appreciate the impact of the problem. Whichever way this the reason, it calls for more impactful education and quality improvement programs.<sup>7–11</sup>

### Patient Consent

The author confirms that the patient has provided adequate informed consent for publication anonymously.

### Author's Contribution

Single author is responsible of all aspects of the article.

### Compliance with Ethical Principles

Formal ethical approval is not required for individual cases.

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### Conflict of Interest

None declared.

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