



Steroid-Induced Hyperglycaemia on the General Ward: A Review of the Predictable Complication That No Specialty Owns

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Abstract

More than one in ten hospital inpatients receives a glucocorticoid, and hyperglycaemia is among the most predictable consequences of doing so. It is also among the least reliably detected. Glucose rises four to six hours after a morning dose of prednisolone and may stay raised for 12 to 24 hours, which means a fasting or pre-breakfast measurement, the one most likely to be taken, is the measurement least likely to find it. Continuous monitoring of patients receiving high-dose glucocorticoids for dermatological disease detected hyperglycaemia in 47.1 per cent, with affected patients spending close to six hours a day above the target range. Incidence roughly doubled with each step in baseline glycaemic status, from 2 of 10 with normoglycaemia to 9 of 10 with established diabetes. In an inflammatory bowel disease cohort, peak glucose occurred on day two in 60 per cent but was not reached until day seven in 14 per cent. This review sets out why the complication is missed, what national guidance recommends, and why responsibility for it falls between specialties.

Keywords: Glucocorticoids; Steroid-induced hyperglycaemia; Inpatient diabetes; Glucose monitoring; Clinical inertia

Introduction

Glucocorticoids are used across almost every medical specialty for their anti-inflammatory and immunosuppressive effects, and more than 10 per cent of hospital inpatients in the United Kingdom receive them [1,2,3]. They raise glucose by increasing hepatic gluconeogenesis and by inducing insulin resistance in liver, muscle and adipose tissue [4,5].

Hyperglycaemia in hospital is associated with prolonged length of stay and increased mortality, and dysglycaemia related to glucocorticoid use has been described as both under-recognised and under-monitored [1,6,7]. The incidence of steroid-induced diabetes is reported at approximately 12 per cent, though estimates vary widely with the method of detection (Figure 1) [8,9,19,20]. The problem has been described as important but overlooked for well over a decade [23,34].

The clinical problem is not that the effect is unknown. It is that the patient is usually admitted under a specialty treating something else, the steroid is prescribed for that other condition, and no one has clear responsibility for the glucose. This review examines the size of the effect, why routine testing misses it, and what guidance recommends.

Material and Methods

Search strategy: PubMed and the archives of the major diabetes, endocrinology and general medical journals were searched for studies of glucocorticoid-induced hyperglycaemia. Search terms combined glucocorticoid, steroid and prednisolone with hyperglycaemia, inpatient, monitoring, continuous glucose monitoring and steroid-induced diabetes. Reference lists of national guidance [10] and practical reviews [3,11] were screened by hand for primary sources.

Eligibility: Studies were included if they reported the incidence or detection of hyperglycaemia in people receiving glucocorticoids, characterised its timing, or set out monitoring or treatment recommendations. Studies in critical care are cited for contrast and identified as such; the focus here is the general ward.

Data extraction and handling: Design, setting, glucocorticoid and dose, the method of glucose measurement and the reported estimate were extracted as published. The method of measurement is stated alongside every incidence figure, because intermittent capillary testing and continuous monitoring produce substantially different answers in this condition and the difference is the point. No pooling or re-analysis was performed. Figures 1 to 6 and Tables 1 to 3 reproduce published values only. This is a narrative synthesis and was not registered as a systematic review.

Results

How often it happens: Estimates depend heavily on how glucose is measured. A study applying continuous glucose monitoring to patients receiving high-dose glucocorticoids for dermatological disease, initiated at prednisolone 0.75 to 2.0 mg/kg daily, detected steroid-induced hyperglycaemia in 47.1 per cent of those treated (Figure 2) [12]. Incidence approximately doubled with each step in baseline glycaemic status: 2 of 10 among those with initial normoglycaemia, 4 of 10 in prediabetes and 9 of 10 in established diabetes (Figure 3) [12].

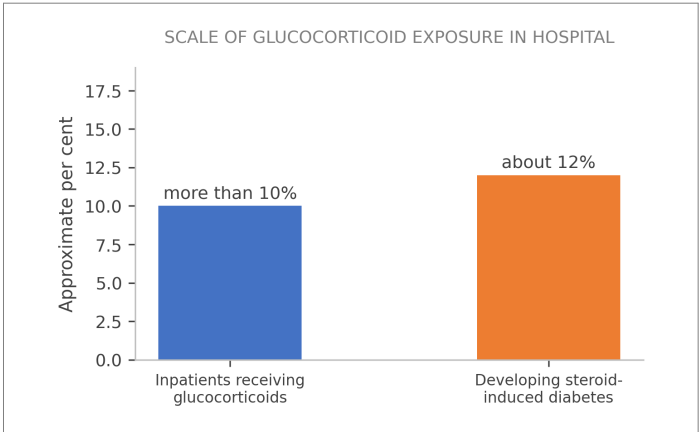


Figure 1: Scale of glucocorticoid exposure and reported steroid-induced diabetes [1,8]

How much of the day is affected: Patients who developed hyperglycaemia spent close to six hours each day above the target glucose range, and severe hyperglycaemia was recorded for approximately 1.2 hours a day (Figure 4) [12]. Those are exposures that intermittent testing at fixed times will represent poorly, and in either direction depending on when the sample is taken.

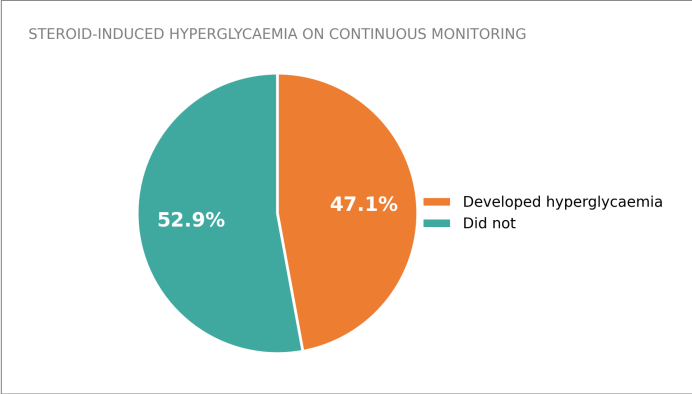


Figure 2: Steroid-induced hyperglycaemia detected by continuous monitoring [12]

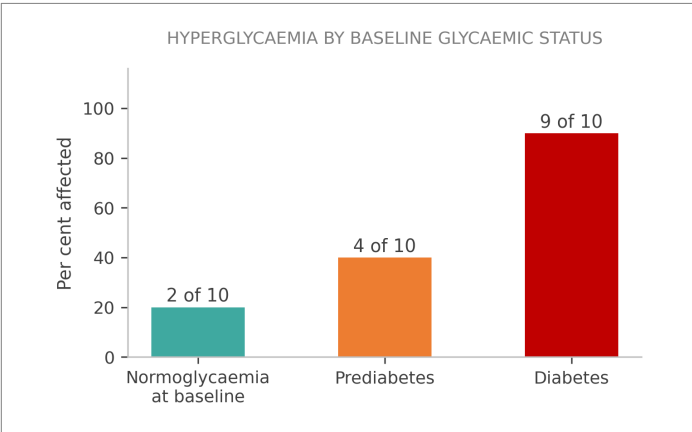


Figure 3: Incidence by baseline glycaemic status [12]

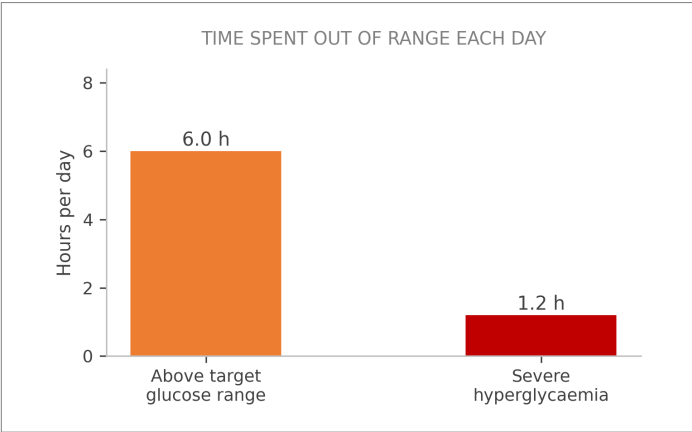


Figure 4: Time spent outside the target range each day among affected patients [12]

Why the timing of the test matters: Glucose peaks approximately four to six hours after a dose of prednisolone and the elevation may persist for 12 to 24 hours (Figure 5) [12,13]. For a morning dose, that places the peak in the afternoon or early evening. A pre-breakfast or fasting measurement, which is the default in many wards, samples the trough. Guidance therefore advises that a glucose measured two hours after a meal, at any time of day, can reliably detect glucocorticoid-induced hyperglycaemia with any regimen, and that monitoring should increase to four times daily if a reading exceeds 11.1 mmol/L [3,10].

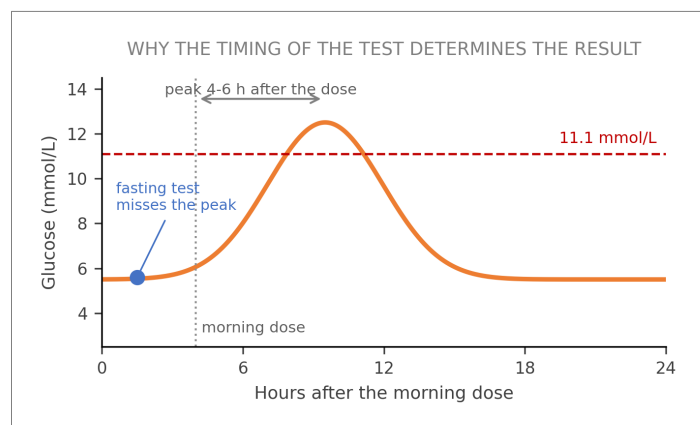


Figure 5: Why the timing of the measurement determines the result [12,13]

How long monitoring should continue: In a cohort admitted with inflammatory bowel disease, peak capillary glucose occurred on the second day of treatment in 60 per cent of hyperglycaemic episodes, but in 14 per cent the peak was not reached until seven days after the first dose (Figure 6) [14]. Mean length of stay was 12.6 days among hyperglycaemic patients against 9.1 days among normoglycaemic patients, a difference that fell just short of conventional significance ($p = 0.053$) [14].

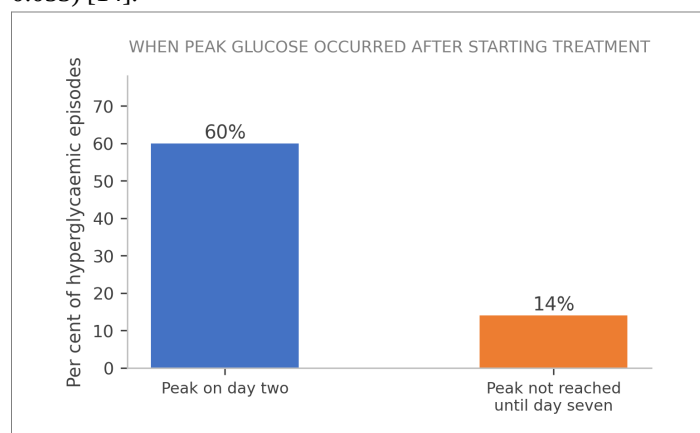


Figure 6: Day on which peak glucose occurred after starting treatment [14]

Study or source	Setting and method	Principal reported finding
Dermatology CGM study [12]	High-dose prednisolone, continuous monitoring	Hyperglycaemia in 47.1%; about 6 h/day above range
Same study [12]	Stratified by baseline status	2 of 10 normoglycaemic, 4 of 10 prediabetes, 9 of 10 diabetes
IBD cohort [14]	Capillary glucose, inpatient	Peak on day 2 in 60%; not until day 7 in 14%
JBDS guideline [10]	National inpatient guidance	Target 6-10 mmol/L; escalate monitoring above 11.1
Swafe et al. 2014 [15]	Audit of bedside glucose measurement	Testing frequency in patients on glucocorticoids is low
Practical guide [3]	Review of monitoring strategy	2 h post-prandial glucose detects it with any regimen

Table 1: Principal studies and guidance reviewed, as reported by the original investigators

What guidance recommends: The Joint British Diabetes Societies guideline for inpatient care sets a general inpatient target of 6 to 10 mmol/L, advises increased monitoring in those with known diabetes and the commencement of monitoring in high-risk groups, and notes that doses equivalent to 5 mg of prednisolone or more are supraphysiological, while cautioning that some individuals develop effects at lower doses [10]. Strict targets are explicitly not recommended where the risk of hypoglycaemia is high [3,10]. Any route of administration can raise glucose, including inhaled, topical, intra-articular and intralesional [3,16,17].

Recommendation	Detail
Inpatient glucose target	6 to 10 mmol/L in general; relaxed where hypoglycaemia risk is high
Detection	Glucose 2 h after a meal, at any time of day, with any steroid regimen
Escalation	Increase to four times daily if any reading exceeds 11.1 mmol/L
Dose threshold	5 mg prednisolone equivalent or above is supraphysiological
Before starting	Exclude undiagnosed diabetes in high-risk groups
Route	Oral, inhaled, topical, intra-articular and intralesional all implicated

Table 2: Summary of national guidance for glucocorticoid-associated hyperglycaemia [3,10]

What happens in practice: Audit of how frequently bedside glucose is measured in inpatients receiving glucocorticoids found testing to be infrequent [15], and the problem has been characterised in the literature as under-diagnosis compounded by clinical inertia rather than as a gap in knowledge [7]. In the inflammatory bowel disease cohort, prescribing did respond once hyperglycaemia was marked: only 30 per cent of patients with a capillary glucose of 14 mmol/L or above received a conventional tapering course of oral prednisolone without some intervention, against 58 per cent of those who remained normoglycaemic [14]. Recognition, when it occurred, changed management. Screening studies in rheumatological disease receiving long-term prednisolone report substantial undiagnosed dysglycaemia [22], and reviews of treatment describe the options once it is found [21,27].

Discussion

The central finding in this literature is not that glucocorticoids raise glucose, which has been known for decades, but that the standard method of looking for it is poorly matched to when it happens. Prednisolone given in the morning produces a peak four to six hours later [12,13]. A pre-breakfast capillary glucose the following day measures the point in the cycle at which the effect has largely worn off. A ward that tests once daily before breakfast can therefore record a run of normal results in a patient spending six hours a day above range [3,12].

That explains the gap between detection methods. Continuous monitoring found hyperglycaemia in 47.1 per cent of a treated cohort; incidence figures derived from routine capillary

testing are considerably lower [8,12]. Both are correct measurements of different things, and the discrepancy should be read as an indictment of the sampling schedule rather than as uncertainty about the underlying phenomenon.

The stratification by baseline status is the most immediately usable finding. If 9 of 10 patients with established diabetes and 4 of 10 with prediabetes develop hyperglycaemia, then a patient's pre-existing glycaemic status identifies who needs monitoring before the first dose is given [12]. That is a decision available at the point of prescribing, and it requires no new test in patients whose HbA1c is already known.

The duration finding deserves equal attention because it cuts against the natural response to the first. Sixty per cent of peaks occurred on day two, which invites a short monitoring window; but 14 per cent did not peak until day seven [14]. A protocol that monitors for 48 hours and then stops will find most cases and will systematically miss a seventh of them, and those are the patients whose hyperglycaemia develops after attention has moved on.

Finally, the ownership problem in the title is not rhetorical. The patient is admitted under respiratory medicine, neurology, gastroenterology, dermatology or rheumatology; the steroid is prescribed for the presenting condition; the glucose is a side effect belonging to a specialty that is not involved [1,7]. National guidance exists and is clear [10], and audit shows it is inconsistently applied [15]. This is a failure of allocated responsibility rather than of evidence, which is why the practical remedies proposed tend to be structural: prescribing prompts, automatic monitoring orders attached to the steroid, and referral thresholds that trigger specialist review [7,14,29]. Insulin protocols designed for this setting exist, and randomised comparisons have examined basal insulin choice, with intermediate-acting insulin matched to the steroid profile a recurring theme [30,31,32,33].

The treatment question sits slightly outside the scope of this review but bears on why detection matters. Because the glycaemic profile of a morning glucocorticoid is predictable, the insulin used to counter it can be matched to that profile, and intermediate-acting insulin given with the steroid has been compared against basal analogues in randomised and retrospective work [31,32,33]. Protocols built around that principle have been evaluated in hospital settings [30]. None of that is available to a team that has not measured the glucose in the first place, which is why monitoring rather than prescribing is the rate-limiting step [15,21].

It is also worth noting what the length-of-stay comparison can and cannot support. Hyperglycaemic patients stayed longer, at 12.6 against 9.1 days, but they also had higher inflammatory markers, and maximum glucose correlated with C-reactive protein in that cohort [14]. Sicker patients receive more steroid and stay longer independently of their glucose, so the association is confounded by indication and the authors did not claim

otherwise.

Study limitations

The limitations belong to the underlying literature. The continuous monitoring study was conducted in a dermatological population receiving high-dose intravenous prednisolone and is small, so the 47.1 per cent figure should not be transferred directly to lower doses or other specialties [12]. The inflammatory bowel disease cohort is single-centre and retrospective, its length-of-stay difference did not reach conventional significance, and hyperglycaemic patients differed systematically in inflammatory burden, so confounding by disease severity is likely [14]. Incidence estimates across the field are not comparable because the definition of hyperglycaemia, the glucocorticoid, the dose and the sampling schedule all vary [8,9,11]. Much of the guidance is consensus-based rather than trial-derived, and the recommended inpatient target of 6 to 10 mmol/L rests on general inpatient evidence rather than on trials in steroid-treated patients [10]. No randomised trial has compared monitoring strategies on patient outcomes. And the literature is dominated by short admissions, leaving the management of glucocorticoids started in outpatient and community settings much less well described [3,18]. General inpatient guidance covers the non-critical setting but not this mechanism specifically [24,25], and the evidence base underlying management has itself been described as thin [28]. Reported prevalence differs markedly between health systems [26].

What would change practice

The interventions most likely to work are administrative rather than clinical. An electronic prescribing system that attaches a glucose monitoring order to any supraphysiological glucocorticoid prescription removes the need for anyone to remember, and the dose threshold for triggering it is already defined in guidance [10,29]. Timing the default measurement to the afternoon rather than to pre-breakfast would align the sample with the peak at no additional cost [3,12,13]. And a referral threshold that generates specialist review automatically, rather than relying on a ward team to recognise a value as abnormal, reflects what the inflammatory bowel disease cohort showed happens once the number is noticed [14].

None of these requires new evidence about the underlying physiology, which is settled, or new drugs, which exist. They require the problem to be assigned to someone. That is the recurring conclusion of the audit literature and it has not changed in the decade since bedside testing frequency was first measured [7,15].

Conclusion

Steroid-induced hyperglycaemia is predictable from the prescription, and its detection depends almost entirely on when the glucose is measured rather than on whether anyone is looking. A morning dose of prednisolone raises glucose in the afternoon, so the fasting measurement most wards default to samples the wrong part of the day, and continuous monitoring accordingly finds hyperglycaemia in nearly half of treated patients where routine testing finds far fewer. Baseline glycaemic status identifies who is at risk before the first dose, and a monitoring window of two days will miss roughly one in seven cases. The evidence and the guidance are both adequate; what is missing is a specialty that regards the problem as its own.

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Conflict of Interest

The authors declare no competing interests.

Ethics Statement

This article reviews previously published studies only. No new patient data were collected and no participants were recruited, so ethical approval was not required.

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