Hypoglycaemia-induced hyperglycaemia (Somogyi effect) is a well-known phenomenon that may occur when diabetic patients are overdosed with insulin, and is one of the most common causes of 'brittle' control and insulin resistance in diabetic dogs and cats. The triggering hypoglycaemic event can be difficult to capture because it often occurs overnight and can be very brief. This presentation will provide tips on how to recognise Somogyi effect in your patients.

**PHYSIOLOGICAL RESPONSES TO HYPOGLYCAEMIA**

The most serious and therefore the most well recognised consequence of insulin-induced hypoglycaemia is neuroglycopenia. This can present as the patient sleeping or hiding more than normal, altered behaviour, dull mentation, pacing/restlessness, weakness, star gazing, ataxia, collapse, seizure, vomiting, and/or bed-wetting. In addition, yowling may occur in cats or trembling in dogs. However, neuroglycopenia occurs only when the animal’s counter-regulatory mechanisms fail.

The release of multiple counter-regulatory hormones is triggered whenever blood glucose concentration decreases towards the hypoglycaemic range. These include glucagon, adrenaline, and cortisol, which together increase insulin resistance and so prevent further lowering of blood glucose. In many cases, the counter-regulatory response will appropriately balance the falling blood glucose concentration so that euglycaemia is maintained during the period of excess insulin action. Some diabetic dogs and cats will thus remain euglycaemic for periods up to several days following an insulin overdose.

Neuroglycopenia results if the counter-regulatory response to insulin overdose is inadequate. In contrast, the Somogyi effect represents an excessive response to hypoglycaemia. The insulin overdose causes a transient period of hypoglycaemia, which triggers release of the counter-regulatory hormones to prevent further lowering of blood glucose. This might result in a period of hypoglycaemia that lasts only minutes and so prevents the animal experiencing the serious consequences potentially caused by low blood glucose. These hormones thus cause life-saving insulin resistance; however, the counter-regulatory response is sometimes excessive and subsequently results in hyperglycaemia that may persist for hours to days. These patients show symptoms of poor diabetic control such as polydipsia and polyuria. The hypoglycaemic event frequently goes unnoticed by owners; it may also occur at night (nocturnal hypoglycaemia) making these events even less likely to be witnessed.

**HOW TO RECOGNISE SOMOGYI**

It is not necessary to document the hypoglycaemic event coupled with rebound hyperglycaemia to identify Somogyi, and this can be very difficult to capture with standard glucose monitoring. The duration of hypoglycaemia can be very short and easily missed by traditional methods of intermittent blood glucose measurement, yet is readily detected using continuous subcutaneous glucose monitoring. The introduction of widespread continuous glucose monitoring in human diabetics revealed that nocturnal hypoglycaemia is more common than was previously recognised, especially in those with good glycaemic control, and the situation is likely similar for diabetic dogs and cats. For example, almost every hypoglycaemic event recorded in the Animal Diabetes Australia patient group over the last 5 years occurred between 12.00 am and 3.00 am (Figure 1 provides an example). Importantly, nocturnal hypoglycaemia can induce the Somogyi effect resulting in hyperglycaemia the following day. Therefore routine day-time blood glucose curves probably miss most hypoglycaemic events and, if Somogyi was triggered, are more likely to record the subsequent hyperglycaemia.

The key to diagnosing Somogyi in diabetic dogs and cats is documenting improvement of diabetic control when the insulin dose is decreased. Substantial improvement can often be achieved with small adjustments of the insulin dose; often with a decrease of just 0.5-1.0 U. The improvement can be immediate or may be gradual over 1-2 weeks. In contrast, dogs and cats with poor diabetic control due to an inadequate insulin dose will typically become much more polydipsic and polyuric within 12 hours of such a trial decrease of their insulin dose. This immediate worsening of clinical signs will confirm that Somogyi was not the reason for poor diabetic control in
those cases, and the previous insulin dose can be promptly resumed and the investigation for another cause continued.

Close attention to the animal’s clinical signs may allow a clinical suspicion that Somogyi is occurring. There is typically a history of good diabetic control for a variable period, which might be very brief or may not have been noted in the patient’s records if the owners did not contact their veterinarian when their pet was ‘going well’. It is important to check if the insulin dose was the same or lower than the current dose during that period. Deterioration of diabetic control often begins with intermittent polydipsia, especially overnight, which sometimes follows a 3-day cycle. The owners might also report unusual behaviours, pacing/restlessness, yowling, vomiting, urinating, etc, especially in the early hours of the morning. In some cases, hypoglycaemia might have been recorded or suspected, and then disregarded as an error.

If the early signs are missed, animals experiencing recurrent Somogyi will present as having “brittle” diabetic control or insulin resistance. **The possibility of insulin overdose causing recurrent Somogyi should be considered for all diabetic dogs and cats presenting with insulin resistance.** These patients show symptoms of poor diabetic control such as polydipsia and polyuria. They might present with very unpredictable blood glucose results that vary anywhere from 1.5-35 mmol/L despite consistent insulin dosing. Key factors include failure to improve with increases of the insulin dose, and weight gain despite otherwise suboptimal diabetic control.

**HOW TO MANAGE AND AVOID SOMOGYI**

Rapid escalation of insulin dose in an effort to ‘stabilise’ the diabetes is the most common cause of hypoglycaemia, Somogyi, and poor control. It is therefore recommended that frequent dose adjustment and ‘micro-management’ of blood glucose is avoided. The animal’s response to each insulin dose adjustment should ideally be monitored for 1-2 weeks before another increase of the dose is considered. It is important that treatment decisions are not based only on results of serial blood glucose curves or fructosamine concentrations without careful consideration of the clinical signs as neither of these methods will reliably identify hypoglycaemia or Somogyi. The goal is for step-wise improvement of diabetic control with each increase of the insulin dose. If there is no apparent improvement with increasing insulin doses, it is important to re-evaluate the patient’s treatment regimen.

If there is clinical suspicion that Somogyi might be occurring, the insulin dose should be decreased, usually by 0.5-1.0 unit, and the animal’s response to the change closely monitored. If clinical signs were previously well controlled, a reasonable approach is to resume the insulin dose that the dog or cat was receiving when there was normal blood glucose is avoided.

Small dogs and cats likely have increased risk for Somogyi because dose adjustments are typically larger in relation to their body weight. For these patients, insulin dosing pens provide more accurate and precise dosing than syringes, resulting in less day-to-day variability of insulin dose and lower risk of insulin-induced hypoglycaemia⁶.

Although clinical signs are a reliable means of identifying periods of poor diabetic control, they are very unreliable at detecting when there is an increased risk of hypoglycaemia. Regular urine dipstick testing for glucose at home is a practical method of monitoring for periods when the blood glucose is below the renal threshold. It is recommended that the insulin dose is reduced and monitoring continued whenever there is persistent negative glycosuria for 1-2 weeks.

**REFERENCES**


**Figure 1:** Serial blood glucose concentration curves from a 12 year old, spayed female, Burmese cat receiving subcutaneous detemir insulin (Levemir® Flexpen®) every 12 hours at 7.00 am and 7.00 pm.

(a) Around the clock serial blood glucose monitoring over 8 days showing nocturnal hypoglycaemia-induced hyperglycaemia (Somogyi effect) on days 3 and 4. Both hypoglycaemic events (indicated by arrows) occurred soon after midnight and were followed by a rapid increase of blood glucose >35 mmol/L. The insulin dose was then decreased by 50% on day 4. There was immediate resolution of the hypoglycaemia and improved glycaemic control within a few days.

(b) Daytime glucose curves for days 2 and 4 showing hyperglycaemia consistently >25 mmol/L. If nocturnal hypoglycaemia had not been identified, the insulin dose may have been increased resulting in worsening clinical signs and risk of severe hypoglycaemia. This portrays a major disadvantage when daytime blood glucose curves are the only information gathered.