

A 2005–2008 Case Study of Canine Diabetes and Challenging Blood Sugar Management

In September 2003, our 9 and a half year old dog, Chris, developed diabetes. The 2-year odyssey of achieving good blood sugar control for him offers a valuable case study for any veterinarian treating canine diabetes. Chris encountered many obstacles along the way—from the beginning, he never did what he was “supposed to do.”

Background

Chris was born in the spring of 1994 of obscure parentage—perhaps Australian Shepherd mixed with terrier or hound—two different DNA tests failed to identify his breeds! He was adopted from a city shelter in September 1994 as a severely undernourished puppy with fleas, ticks, worms, and kennel cough. As that started to clear, we discovered he had a severe patent ductus arteriosus (PDA). His heart couldn’t keep up with his growing body and we were afraid we would lose him before he could get well enough for PDA-correcting surgery. Fortunately, he came through the surgery (Thank you Dr. G.) with flying colors and grew into a happy healthy dog weighing about 60 pounds.

In August 2003, he was given Temaril-P® for a severe allergy attack. His drinking and urinating increased dramatically and did not return to normal after the steroids were removed. Because he was ill and tachycardic, we took him in on an emergency call the night of September 7, 2003. He was diagnosed with diabetes with a blood glucose level of 352 and an inflamed bowel. Initially, he was prescribed 14 units of lente insulin, Humulin® L, twice daily and was put on Science Diet WD®.

Chris’ Insulin “Honeymoon”

Over the next few months, Chris’ periodic blood glucose curves showed his blood sugar running too low and his insulin dose was incrementally decreased after each curve. In January 2004, his blood glucose on 5 units of L

twice daily (down from 14) ran from a high of 96 to a low of 68. Chris exhibited mild signs of hypoglycemia

whenever his blood sugar dipped into the 60s. Presumably, he was “honeymooning” thanks to residual insulin production. By March 3, Chris was down to 1 unit of L twice a day with blood glucose in the mid-hundreds.

But just a week later he started to show glucose in his urine again. On March 23, his blood glucose was 563. A curve done April 8 while Chris was on 2 units twice a day ranged from 560 to 447. The honeymoon was over. Chris’ vet suggested that we start home testing and referred him for specialty care at a teaching hospital.

Chris and Lente – Humulin® L

At the teaching hospital, the veterinary resident put Chris on a conservative dose of 5 units of Humulin® L due to concerns about Somogyi effect, in which the dog’s body, in response to blood sugar that is too low, releases large quantities of stored glucose, abruptly sending the blood sugar too high (See Figure 2). We began to incrementally increase Chris’ insulin dose, evaluating his response with curves, and his care was returned to his general practice veterinarian. The vet performed the first curve, comparing his readings with our meter. After that, we did Chris’ blood glucose curves at home.

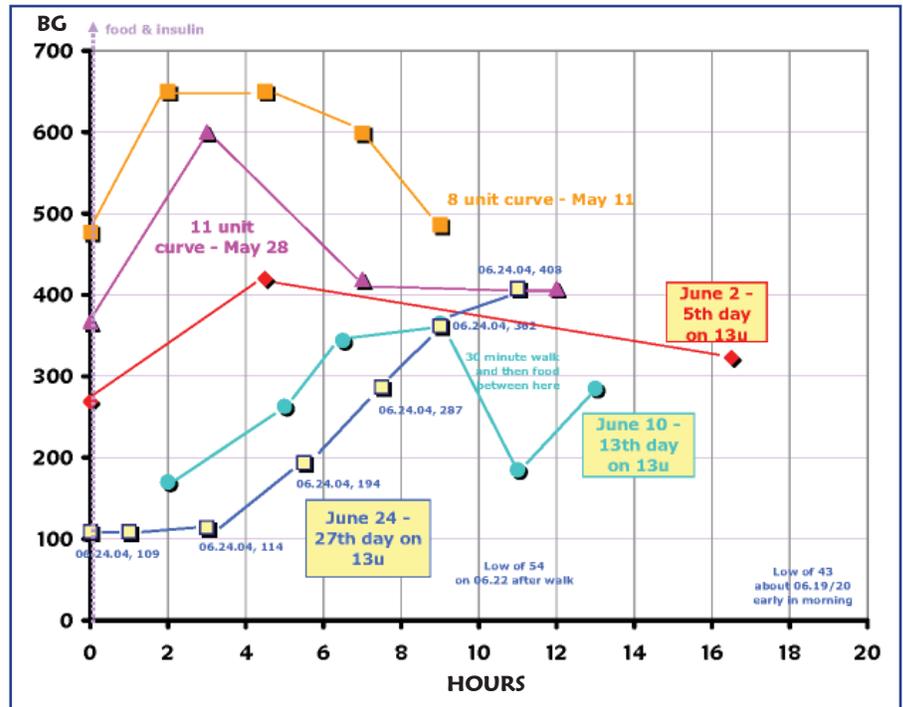


Chris on May 12, 2005.

In May and June, we did several curves of Chris' response to L as his dose was gradually increased—from 5 units to 8, then to 11, and finally to 13 units twice a day (See Figure 1). We were disturbed by the curves—the more L we gave him, the wider the gap between his high and low blood sugar readings. Chris' residual insulin production the preceding 6 months had masked how Chris' body actually absorbed and used the lente insulin. After 27 days on 13 units, the curve showed Chris' blood sugar starting out relatively low (109) and then rising steadily over the next 11 hours to more than 400.

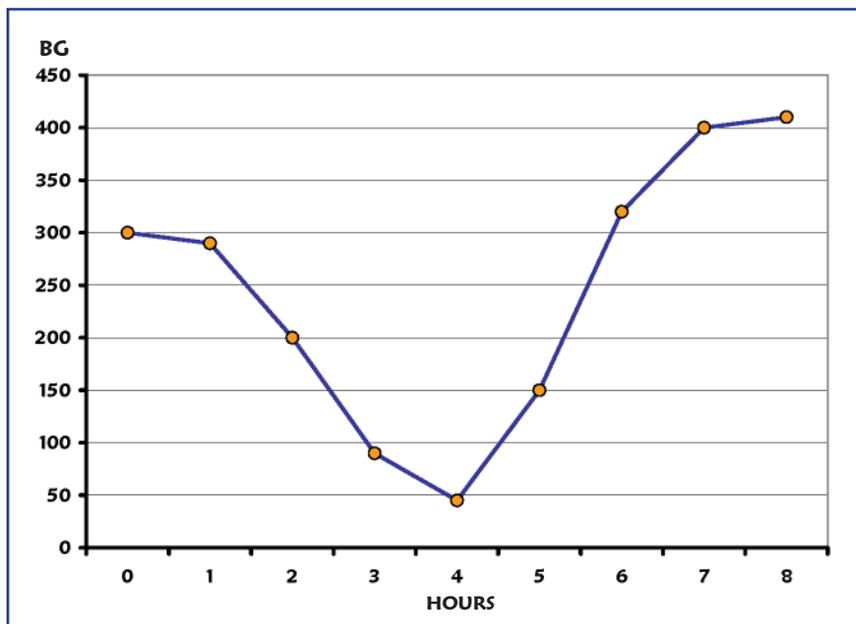
As a consequence, Chris was referred to an endocrinologist for evaluation of the curves on July 6, 2004. The endocrinologist appears to have applied conventional wisdom in canine diabetes management—flat curves with numbers that are all too high mean the dog needs more insulin; steep curves with large swings between high and low readings mean

Figure 1. Curves in May and June, 2004, while Chris was receiving Humulin® L twice daily.



the dog is rebounding from lows (Somogyi Effect—see Figure 2) and so requires less insulin. The endocrinologist recommended reducing Chris' insulin dose and stated emphatically that “Chris is on the right insulin. Don't change it. It's working.” Chris' veterinarian, deferring to that advice, wanted to keep Chris on L.

Figure 2. An example of a blood glucose curve when a dog is experiencing the Somogyi Effect. This “rebound,” a large release of stored sugar, is the body's way of protecting itself from hypoglycemia and can result in both very low and very high glucose levels in a 12-hour period.

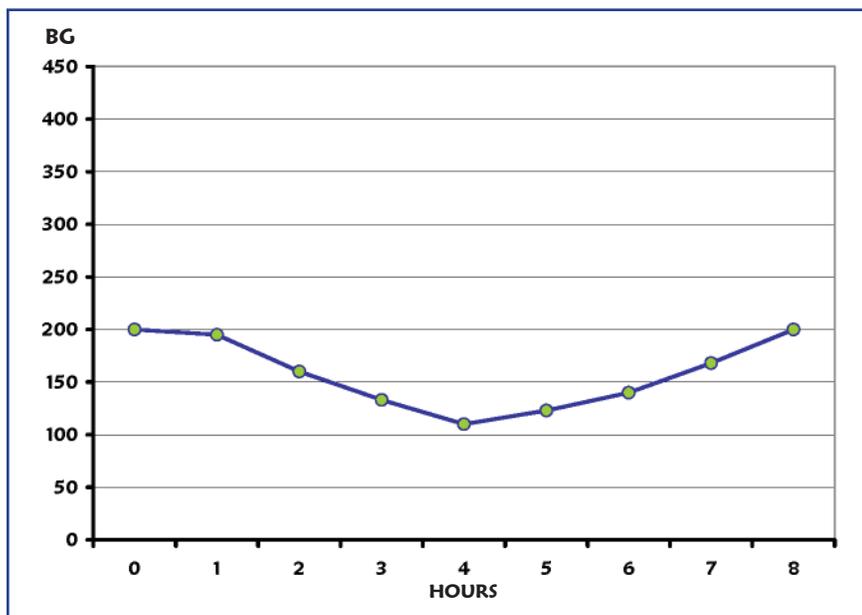


Why Humulin® L Did Not Work for Chris

Evaluations of Chris' use of Humulin® L missed a key point—the insulin did not start to significantly affect Chris' blood sugar until 7 to 11 hours after injection. The curves gave an objective picture of how Chris processed lente insulin, then and later, as we would learn.

Figure 3 shows an example of an ideal blood glucose curve where the meal and insulin injection/dose are well matched. After feeding and injection, the dog's glucose levels may first briefly rise if the influx of sugar from the meal exceeds the insulin's action during the first few hours.

Figure 3. An example of an ideal blood glucose curve over 8 hours.



Overall, however, the insulin's action should keep the blood glucose fairly level between meals with only a small decline. Chris' curves (See Figure 1) showed a very different response. Sugar was pouring into his bloodstream from his food for hours with no compensating insulin activity.

In 2005 Chris again demonstrated the same response to L—no significant lowering of his blood sugar until 7 to 8 hours after injection, at which point it was metabolized and used up quickly. More on that later.

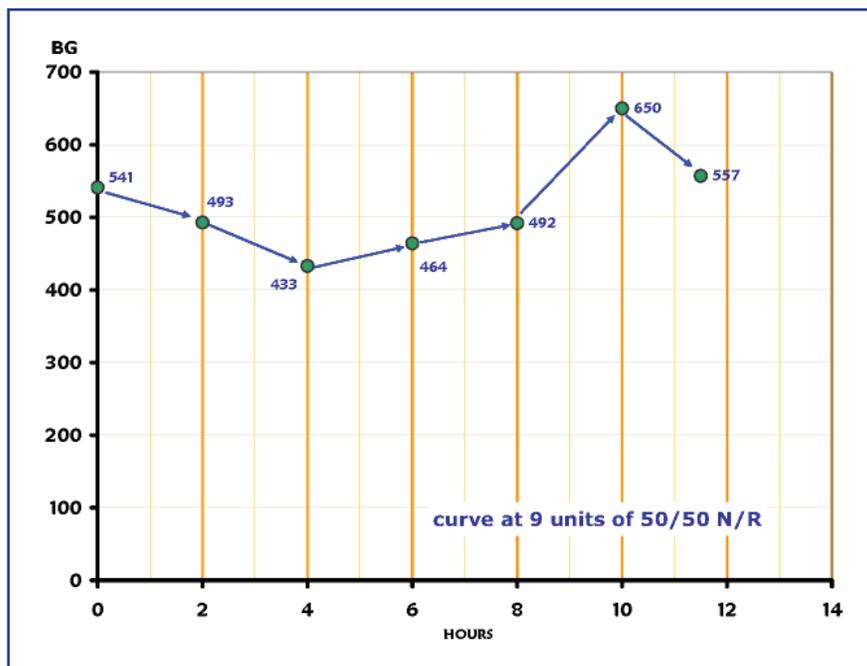
It is important to note that Chris was losing his vision early that summer to diabetes-induced cataracts because of the months he spent very poorly controlled. Had we learned to understand glucose regulation and started home testing immediately after his diagnosis, we might have saved his sight.

Chris and Humulin® R

Because we disagreed with the endocrinologist's assessment (though at the time we did not understand *why* it was wrong), we had Chris evaluated by another veterinarian who agreed to try different insulin (Thank you Dr. T.). Chris was given Humulin® 50/50 (N/R) at 9 units and a curve was done after about a week (See Figure 4). The two veterinarians who reviewed this curve on August 10, 2004, were not satisfied with the insulin's effect and referred Chris to a second endocrinologist.

On August 17 the second endocrinologist reviewed all of Chris' blood glucose curves and recommended increasing his insulin and either continuing Humulin® 50/50 twice daily or using Humulin® R (Regular) 3 times a day (every 8 hours). We chose R since we could accommodate the 3 injections and were concerned about insulin-absorption delays.

Figure 4. Chris' blood glucose curve on 9 units of Humulin® 50/50 twice daily—Actually, a pretty good shape, but not enough insulin and a lack of duration.



Chris' first blood glucose curve on a regimen of R, shown in [Figure 5](#), was completely different from curves on L. The insulin started working quickly and rapidly reduced his blood glucose levels, peaking about 3 hours after injection. However, Chris' tendency to rapidly metabolize insulin once it takes effect was again apparent. His blood sugar started to rise rapidly about 6 hours after injection, which was 2 full hours before his next dose.

Figure 5. Chris' first curve after beginning R three times a day.

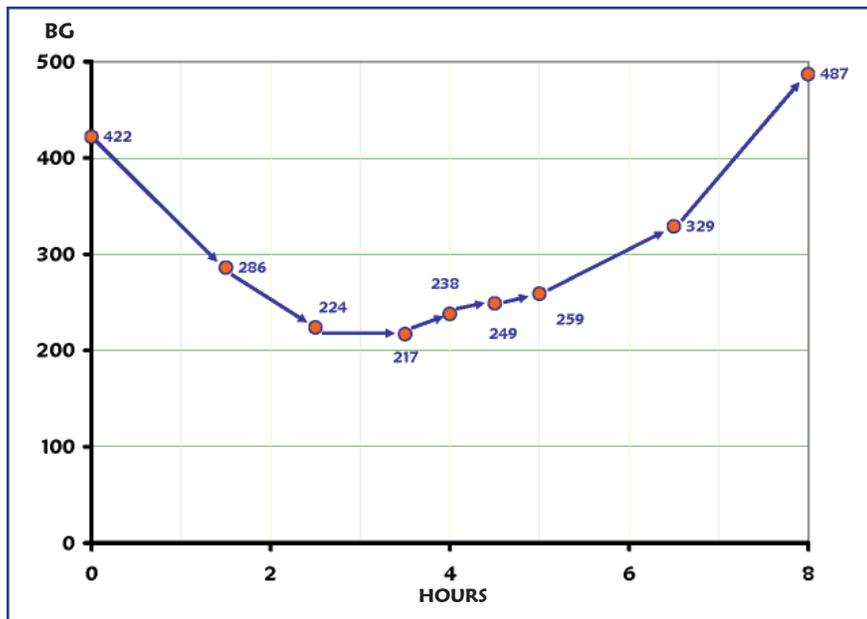
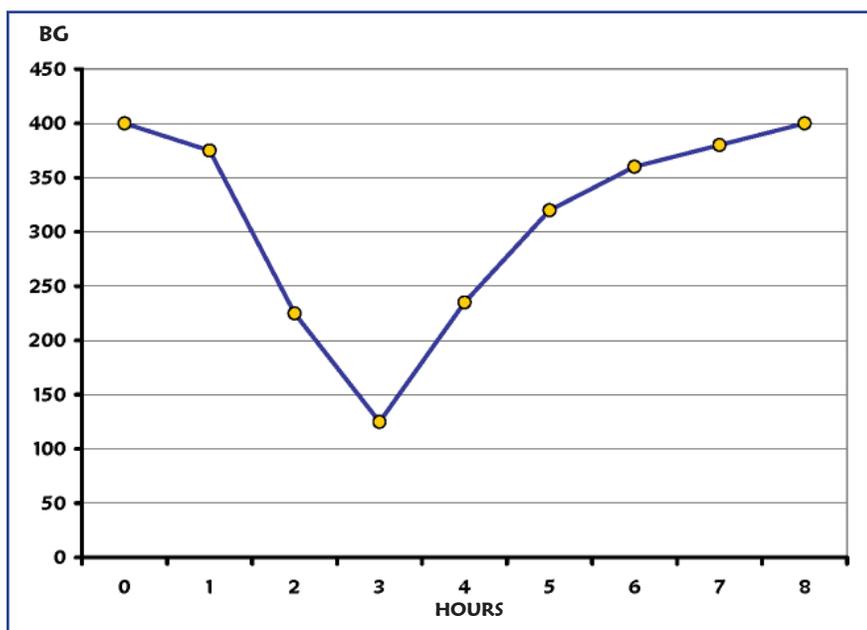


Figure 6. A sample blood glucose curve where insulin is rapidly metabolized and lacks duration.



[Figure 6](#) shows a blood glucose curve that suggests rapid metabolism of insulin, resulting in a lack of duration.

Chris generally did well on R. He felt better than he had in a long time with R plus Metacam® for arthritis. But the speed with which he metabolized the insulin continued to be a problem. His starting level was too high and we could not get the highest numbers into a good range without him experiencing dangerously low blood sugar at the nadir ([see Figure 7](#)). So we tried adding some NPH insulin to extend the effect.

Chris and Humulin® N (NPH)

On R alone, Chris spent about two-thirds of the day with blood glucose in a good range but went higher than we liked the rest of the day ([see Figure 7](#)). In an effort to improve his control and flatten out his curves, his veterinarian suggested adding N to his regimen. Starting in the fall of 2004 and continuing into 2005, we experimented with N and R in various combinations on a 3-injection schedule.

As we measured and plotted his blood glucose, it became clear that Chris processed N only a little slower than R, getting only about 8 hours of insulin activity per injection. Over the course of weeks, we transitioned him to N alone by slowly shifting the ratio of R and N in 1-week increments until Chris was receiving only NPH 3 times a day. His blood glucose control, as shown in a sample curve in [Figure 8](#), was the best it had ever been.

Unfortunately, the more N Chris was given the worse he felt. By the time he was on N only, he could not tolerate walking a block. This decline coincided with the increasing quantities of N insulin, so we reluctantly removed N from the equation

and went back to R only. His energy and general demeanor improved as soon as the N cleared his system. Chris is apparently allergic to protamine, which is contained in NPH but not in R or L.

Adjusting the Timing of Injections

We were running out of options once N had to be eliminated. To get Chris in a better range more hours each day, we adjusted the timing of his injections to a 7•7•10 schedule. He was fed and injected at 7 a.m., 2 p.m., and 9 p.m. with 7 hours between injections during the day and a 10-hour stretch at night. This worked well for cutting off the high levels of blood sugar Chris reached during that last hour of the 8-hour schedule. He still went high at night but spent 3 or 4 hours with high blood sugar daily instead of 9 hours.

Using L's Delayed Action to Help Chris

By April 2005 we had learned a great deal about diabetes, insulin actions, reasons for problems with blood glucose control, and detailed means of blood sugar management in humans and canines. We had also learned—at an incredible level of detail—what Chris did with food and insulin through months and months of home testing.

We went back through all of the data we had collected looking for a way to get Chris below 300 for more of the day. After reviewing his curves from his days on L, we realized that we might be able to use his insulin-processing delay to our advantage. We put Chris briefly on 2 injections a day of R and L to see if he still processed the L insulin late and how long it stayed in his system. True to form, Chris got little

action from L until 7 hours after injection and its effect did not last—once absorbed, it was metabolized quickly since his meal earlier in the day was long gone. This allowed us to combine R, which started working quickly and lasted 6 to 7 hours, with L, which did not start working until 7 hours after injection, to keep Chris' blood sugar in a good range through the night.

Figure 7. Chris' typical response to R three times a day.

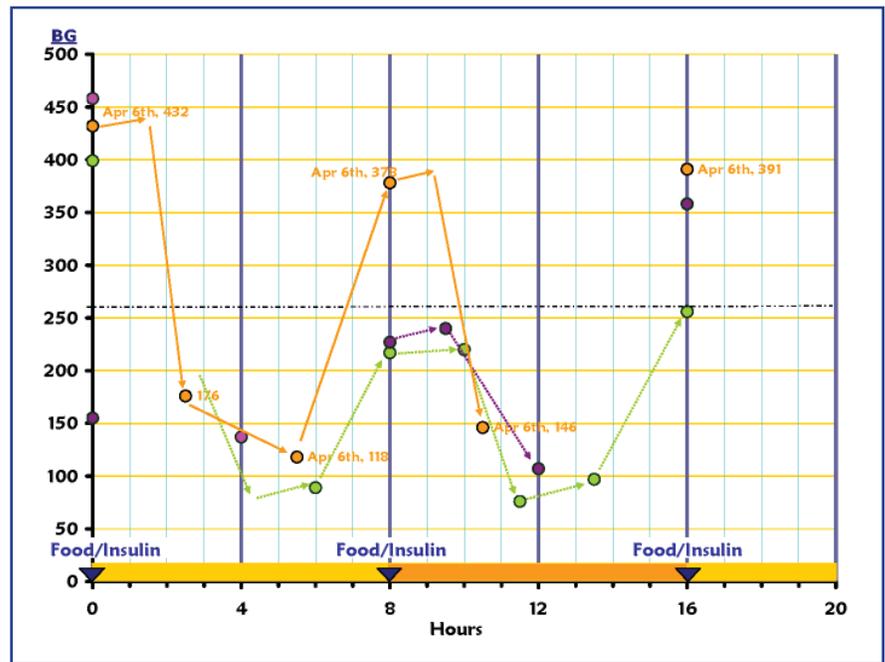


Figure 8. Chris' response to N three times daily (every 8 hours).

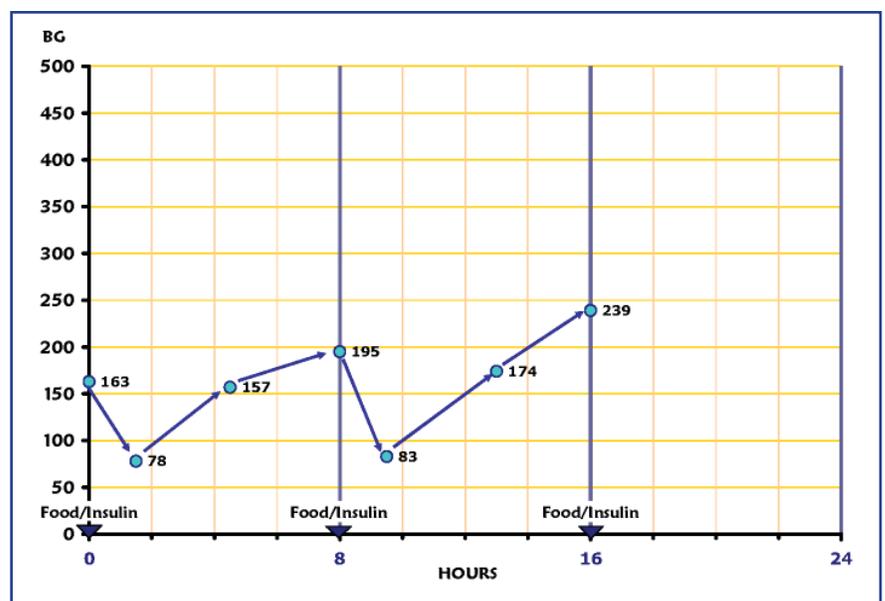
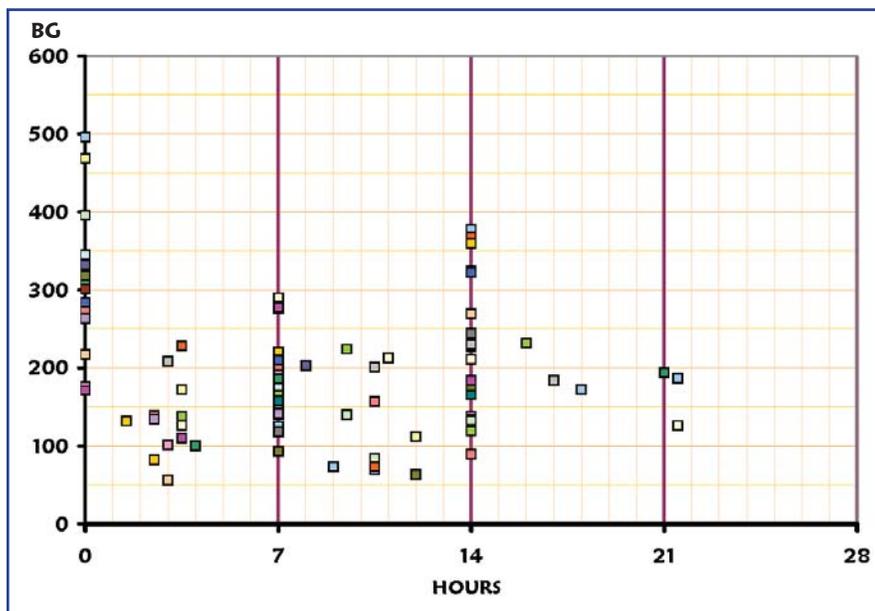


Figure 9. Testing in April and May 2005 with Chris on a combination of R and L.



Briefly, a 7-7-10 Schedule of Regular and Lente

We put Chris on three injections daily.

- 7 a.m. – 7 units Humulin® R
- 2 p.m. – 7 units Humulin® R
- 9 p.m. – 7 units Humulin® R + 4 units Humulin® L

Figure 9 shows readings from the time we started testing R and L in combination. We proceeded cautiously to be sure the R and L were not doubling up. Once we felt comfortable that he was not experiencing any overlap, we raised his dose of L and began to see morning readings typically between 200 and 350 with the rise occurring only in the last hour or so.

Before we could perfect this system, however, Lilly announced in mid-2005 that it was going to cease producing Humulin® L at the end of the year.

The Last Three Years

After the announcement about Humulin® L, we opted to change Chris' insulin regimen immediately.

Based on curves we had done when we first used R 3 times a day, we switched Chris to 4 injections of Regular insulin daily at 6-hour intervals since we had already seen that for him R did not last 8 hours. This regimen worked

very well for Chris, generally giving him blood sugar levels between 100 and 200, and we used that schedule for the rest of his life. We were incredibly fortunate that our work arrangements made this challenging schedule possible.

Chris passed away on August 1, 2008, at 14 and a half from cancer and his blood sugar was well controlled to his last breath. We can't begin to describe how much we miss him... His struggles to regulate inspired us to start a new website for canine diabetics, www.k9diabetes.com so that his experiences could help other dogs.

Summary of Chris' Insulin Profile

- L consistently had little effect until 7 to 8 hours after injection and then lasted only a few hours.
- Chris metabolized all insulins quickly, resulting in reduced duration. He got about 6-7 hours from Regular, 8-9 hours from NPH, and just a few hours from L once it finally started to act.
- Chris was allergic to the protamine in NPH.
- Chris' blood sugar was finally best regulated on **Regular insulin given every 6 hours** (4 times a day).



Analysis

There are many lessons that can be learned from the long road we had to travel to finally get good regulation for Chris.

- Too much anxiety and attention was initially focused on the possibility of Somogyi rebound and not enough on evaluating objectively what Chris' blood glucose curves were telling us.
- A blood glucose curve tells a unique story that is obscured by trying to fit it into one of a few expected patterns. Chris' curves on L gave a clear picture of how he processed that insulin even though they did not look like they were expected to look.
- Information is available by which to evaluate and treat difficult or "atypical" cases of regulation, but the expertise necessary probably extends beyond the training of many veterinarians and even of diabetes experts who are not primarily clinicians. When the dog does not respond as expected, veterinarians need tools and training to allow them to evaluate and tackle the problem.
- Blood glucose curves in a fair amount of detail are crucial to analyzing how a dog processes food and insulin when regulation is difficult. Urine testing and spot checks will not resolve questions of insulin use.
- Good regulation should be pursued more often and more aggressively in challenging cases. Chris' regulation was achieved by first learning in more detail about the interaction of food and insulin and then applying that knowledge to tests of various insulin preparations, assessing the results of each change with serial blood glucose curves. Had that kind of research been done at the first sign that Chris was not responding in a typical way, he might have retained his sight.
- Regular testing plus careful observation was the only way to sort out the many issues involved for Chris and rarely could an owner afford to have a veterinarian perform such testing. For difficult cases, home blood glucose testing may be the only effective way to evaluate responses and determine a functional regimen.
- Ideas that home blood glucose testing is unnecessary, cruel, obsessive, and/or inaccurate are outdated (to see Chris looking bored and decidedly unstressed while having his blood sugar tested, see www.k9diabetes.com/bgtestvideos.html) and not supported by our experience or the experience of dozens of others with whom we correspond. Ideally, veterinarians will encourage home blood glucose testing, especially in challenging cases, and use the information it provides. In our case, we learned to use the information to help our dog.
- "Typical" is not a very useful term with diabetic dogs. We have learned that dogs present a dizzying array of unique responses to food, insulin, exercise, pain, and stress—good or bad. What regulates one dog is a nightmare for another. Each case has to be approached individually and without preconceptions.
- The best hope for dogs like Chris is more extensive training for veterinarians in day-to-day management of diabetes that aims for good regulation and is based on techniques used by human diabetics, along with recognition that each case is an individual puzzle to be solved and one that is worthy of being solved.
- While dogs may do okay with only minimal regulation of their blood sugar, aiming so low potentially robs a dog of the best quality of life possible. The best regulation that can be achieved with safe blood sugar levels is a worthwhile goal.

Key Elements of Good Canine Diabetes Treatment

The following are essential elements of good diabetes care for dogs based on our research and experiences and the experiences of many others.

- *NPH* and *Vetsulin/Caninsulin*[®], a lente insulin, are currently the two main insulins used with dogs and both have proven track records as effective. *Lantus*[®] (glargine) has so far not been proven to be a reliable insulin for dogs—it has worked well for some but poorly for many others (Chris was one who got very sharp swings in blood sugar on *Lantus*[®]). Longer acting insulins (ultralente types) generally do not work well in dogs and it remains to be seen how *Levemir*[®] might work.
- Two injections of insulin per day 12 hours apart is the best standard approach in the beginning. Few if any dogs maintain good blood sugar control on 1 injection per day—as true for *Vetsulin/Caninsulin*[®] as for *NPH*. Some dogs, like Chris, will eventually require a different schedule or number of injections for good regulation but 2 per day is the place to start. The safest way to introduce insulin and avoid overdosing is to start with a dose that is presumed to be low (no more than 1/4 unit per pound) and work up gradually to the proper dose.
- Urine testing is not a good tool for monitoring blood sugar while establishing an insulin dose in a new diabetic. Little information comes from urine testing at this stage. Once a dog is regulated, urine testing is one way to monitor regulation.
- Frequent blood glucose curves—testing the blood sugar every 1 to 2 hours over at least 8 hours, preferably 12 hours (the entire cycle of an injection of insulin), and ideally longer to check for overlap

of intermediate-acting insulin doses—is the best way to evaluate a newly diagnosed dog’s diet and insulin to see if they are well matched and how each is being processed by the dog’s body. These can be done by the vet (especially the first one or two) and/or by home blood glucose testing.

- The information provided by blood glucose curves should be relayed and explained to dogs’ caretakers to assist them in timing exercise and help them monitor for hypoglycemia at the dog’s typical nadir (lowest blood sugar).
- Conventional wisdom about diets high in fiber for diabetic dogs is falling by the wayside as more and more vets find that many kinds of diets work as well or better, especially with *Vetsulin/Caninsulin*.

Acknowledgments

Ultimately, Chris’ regulation could not have been accomplished without the internet, which allowed us to educate ourselves about diabetes management, in people and in dogs. Links to many of the sites we used can be found at www.k9diabetes.com.

We also gratefully acknowledge all of the people we met online and in person along the way who shared their journeys with their diabetic dogs and the wisdom they gained in the process.

For more information about Chris and about managing diabetes in dogs, please visit our website, which is dedicated to Chris’ memory: www.k9diabetes.com.

We are solely responsible for the content of this study.

We wish all diabetic dogs the best care that both
human and canine medicine can provide,
Chris’ Caretakers