



Amarillo Medical Specialists, LLP

Endocrinology Division

Technical Notes for use of IV Insulin Drip Protocol

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1) Introduction

Improved insulin control for hospital inpatients is always a challenge, due to the unpredictability of their calorie intake, physical stressors such as infection, surgery, or medications, plus the individual variation in insulin sensitivity.

“Sliding Scale” protocols without any basal insulin are generally suboptimal, but very widespread. Their popularity appears to derive from their ease of use, reduction of phone calls to doctors, and a misconception by some medical and nursing staff that they improve blood sugar control.

As more physicians recognize the benefits of improved outcomes when glucose is tightly controlled, we have had more interest in developing IV insulin protocols.

2) IV Insulin Protocols compared and evaluated:

There are many IV insulin protocols published, with good data on their outcomes. We evaluated the Portland Protocol, the DIGAMI Protocol, and the Leuven Protocol. We were also given a copy of the protocol used by Bruce Bode, MD and his associates at Atlanta Diabetes Associates.

After clinical use in our private practice setting, we found the Atlanta Protocol was superior in several respects.

3) Why we chose the Atlanta Protocol.

When we did our original evaluation, the Portland Protocol used a target glucose range that is significantly higher than is currently felt to be desirable. It stopped insulin below a BG of 100mg/dl. It is recognized that even these higher levels of BG are an improvement for many patients over historical diabetes management. More recent versions of the Portland Protocol have been released which may address these issues. The Portland Protocol requires many nursing level decisions that are difficult to implement on a consistent basis on each shift. Deciding if a glucose level has dropped 10% is not necessarily intuitive to some ICU nurses. Although we had no major errors in our testing of this protocol, the BG levels

fluctuated more with any new stressors or initiation of feedings due to the 0.5u/hr limitation of change in the infusion rate.

We have received some comments that we used an earlier version of the Portland Protocol and we might like the newer one better. Indeed, we have not tested the latest version; however our results with the Atlanta protocol have been so favorable that we are unlikely to change at this point.

The DIGAMI protocol likewise makes only 0.5 or 1.0 u/hr adjustments. It was easier to use and understand for the ICU nursing staff, but also had target glucose levels higher than currently felt to be optimal.

The Leuven Protocol has one of the tightest available control levels, with a target BG of 80 -110, but the protocol is also hampered by its limitation of dose adjustment by 1 or 2 units. There is no fine tuning available that would reflect a patient who keeps jumping between 2.0 and 3.0 units. A feature of this protocol is that, once stable, the fingerstick BG is tested only every 4 hours. In the ICU setting, we were not entirely comfortable with running glucoses in the 80 – 110 range on sedated or ventilator patients with glucoses every 4 hours.

The Yale protocol has also gained wide acceptance. This was released after we had fully adopted the Atlanta Protocol. It appears to be substantially more complicated than the Atlanta Protocol. We have found that complexity is associated with more potential for error.

The Atlanta Protocol, also referred to as the “Continuous Variable Rate IV Insulin Drip” was supplied to us courtesy of Bruce Bode, MD at Atlanta Diabetes Associates. It reportedly is the basis for the Glucommander program, which has some additional refinements. This protocol is unique in that it makes changes based on *multiplier*, or a surrogate for insulin sensitivity. It then changes the insulin rate hourly based on the difference between the measured BG and a target BG.

We have found several advantages to this approach:

- a) For excessively high BG at initiation, it provides enough insulin for rapid normalization of glucose, and also rapidly reduces the insulin infusion rate when BG levels normalize.
- b) It makes small, incremental changes to the infusion rate even while the BG is in the target range. In our use, the insulin infusion typically settles into the center of the target range, and then stays very close to that. None of the other protocols had this feature.
- c) The insulin drip goes to very low levels if the BG gets below target, and any D50W administered is titrated to the degree of hypoglycemia rather than a preset, arbitrary, amount.

In short, this protocol provides rapid correction of blood glucose and also titrates down to a stable maintenance dose rapidly. The math behind the protocol is both elegant and simple, and does not require the nursing staff to make complicated decisions based on rates of change. Implementation in a community hospital should not be difficult.

4) **How we modified the Atlanta Protocol.**

The basic algorithm supplied by Dr. Bode is unchanged; however we modified the order sheets to clarify certain aspects of the protocol for the ICU nursing staff. Our goal was to make the instructions “bulletproof” or less susceptible to misinterpretation.

Our hospitals use infusion pumps capable of infusion adjustments of 0.1 ml/hr, and we have historically mixed insulin in a 1.0u/ml ratio rather than Dr. Bode’s 0.5u/ml ratio. By using a 1:1 ratio this not only conformed to our previous protocols, but eliminated one calculation step. (Note: Our example flowsheet on the web is our original, thus it still has a 0.5:1 ratio.)

Certain items were misinterpreted in the initial drafts of our order sheet, so have modified the order sheets and flow sheets to reduce the chance of any medication errors. The most common error involved recognizing the target range. We would specify 80 to 110 mg/dl for instance. However the protocol uses a computation of $[BG - 60]$ which some of the nurses would misinterpret as the target range, leading to glucoses exactly 60mg/dl above the desired value.

We added language re-emphasizing the hourly recalculation step. Since some night and weekend nurses were familiar with older protocols where there was *no* change in IV insulin infusion for a BG in target range, they had not read the part of the protocol telling them there was an hourly recalculation necessary. We added black boxes as a separate line item reminding them of this.

Since most ICU patients are managed as part of a multidisciplinary team, other physicians may make changes that impact glucose control. The biggest challenges are adding TPN, feedings, or steroids. We occasionally have patients who go back to the OR with insulin running, and when they return from the recovery room the insulin drip is off and the glucose is 300. Thus we ask to be notified of the insulin being turned off, so we can have some input into whether or not this is a good idea, and at least be prepared to compensate when the patient returns to the ICU.

We designed a flowsheet that has clearly identifies the target range, and helps the nurse with the calculations. Also, we provided an example flowsheet that demonstrates what happens when the glucose is above target, below target, or hypoglycemic.

5) **Staff Training**

This is a continuing task, however we found that once a critical mass of nurses were in serviced, then there was always a nurse on the unit who was experienced in the protocol and could mentor a nurse using it for the first time.

Once implemented, this actually turned out to be the best accepted protocol by the nurses, because it did the best job controlling the BG and at the same time had the lowest incidence of hypoglycemia. The nursing staff has a high level of confidence in this protocol.

Our initial in-service included information on why the sliding scale doesn't work well, why our BG targets have dropped to lower levels, and how to calculate the doses.

Sessions for doctors at departmental meetings, Grand Rounds, hospital staff meetings and the like were made to educate the staff on the inherent deficiencies of the sliding scale, and the availability of IV insulin alternatives.

6) Disadvantages

This protocol as currently written uses hourly BG measurements. In our opinion the vastly improved control outweighs this disadvantage. In addition, we have had several stable, long term ICU patients on ventilators, TPN, etc., where we reduced the monitoring to q2 or q3 intervals. Our longest non-stop IV insulin drip so far has been 6 weeks.

Do we continue q 1 hr BG testing forever ? Not necessarily. If the endocrinologist determines that the insulin "multiplier" has been stable for several hours, he/she can instruct the nurses to go to q 2 hour testing. We might write this as "May check BG q 2 hours if there has been no change in the multiplier for the previous 4 hours."

7) Safety

Given the short $t_{1/2}$ of insulin, it should be inherently safer than sq insulin. Our nursing staff continues to view IV insulin as a high risk treatment, thus we have excellent compliance with hourly monitoring and use only via IV pump. In order to "spare" the patient from frequent fingersticks, some RNs were found to be obtaining blood from other sources, such as a CAVHD machine. This can lead to inaccuracies in measurement, and is not allowed. In some circumstances a central line can be used to measure the BG. We want to be notified about this so we can verify that the correct port is used, and reduce the risk that an inaccurate BG is obtained.

Be aware that certain bedside meters, such as the Accucheck, can have falsely elevated readings when the patient is on IV IgG or using ExtraNeal for peritoneal dialysis. In these cases we use meters not affected by the patients medications, such as a One Touch.

8) Physician Buy-In

Non endocrinologists have started to recognize how well this protocol works for us, and have adopted it as well. A thoracic surgeon has incorporated this algorithm into a standing order. The local Internal Medicine residents have discovered our protocol as well.

The change in physician behavior appears to occur not with the recognition that this IV insulin protocol is better than the previous ones employed; that is generally accepted.

The inflection point is when physicians recognize that good diabetes control is even necessary to improve their patient's outcome. Thus some surgeons continue to use a sq sliding scale approach postoperatively.

Anesthesiologists have been one of the slowest groups to accept IV insulin for a variety of reasons....."I don't want one more IVAC", "I have too much to do already", "I am in charge here, not you", "It's only for 3 hours".

Anesthesiologists continue to represent an opportunity for improvement, but we do have a number who will run the protocol for us. We try to steer the surgeons toward using those anesthesiologists. In discussing this with protocol users around the US, this appears to be a nationwide issue and not localized to our community.

9) Hospital Buy-In

The hospitals have been quite accepting of the new protocols, particularly when the actual results have been reviewed. They are sensitive to the fact that not all physicians accept the need for tighter control, but they willing to in-service the nurses and pharmacists in this project. Some physicians have standing orders written years ago that include a 'one size fits all' sliding scale. Usage of sliding scales appears to be diminishing, but it will probably be years before it becomes extinct. Part of our educational process is educating other specialists on how good control will help them. It will not be an overnight endeavor.

We have found hospitals to be receptive to prohibiting 'sliding scales' from routine printed standard orders. As 'sliding scales' become less acceptable, hospital administrators are often astute enough to realize they don't want the hospital logo orders that include a 'sliding scale'.

10) CHO supplementation

Some experts feel that the improved outcomes seen on IV insulin are not only from lower BG, but also better intracellular fuel utilization. Insulin has direct beneficial effects on cytokines, inflammatory mediators, free fatty acids, MMPs, PAI-1, etc. that are not directly mediated by plasma glucose.

Thus many advocate a CHO source as part of their protocol. This issue is not addressed in the Atlanta Protocol, however our endocrinologists typically use D5NS or D5 1/2 NS to provide a source of glucose. This also appears to reduce the

degree of fluctuation of the BG, although we have not systematically studied this issue. We explain this rationale at our nursing in-services, since the addition of glucose to the IV fluids is frequently questioned.

This protocol works well for patients on TPN, and we encourage the writers of the TPN orders to resist the urge to add insulin to the TPN when our drip is running. Having two sources of insulin makes the calculation of the insulin infusion rate difficult. In the event that the TPN runs out, our TPN protocols call for D10W to start, reducing the risk of hypoglycemia.

Enteral tube feedings are generally not a problem with the protocol if they are given by constant infusion. The protocol adjusts rapidly enough to compensate quite easily for addition or subtraction of tube feedings.

If tube feedings are held, for endoscopy, surgery, dialysis, etc., it may be prudent to reduce the *multiplier* by half and allow the drip to reequilibrate from that point.

Once the patient is taking significant calories by mouth, we have found all the protocols are unable to fully compensate for CHO at meal times. This is the point where many patients are able to be switched to subcutaneous insulin, making this a moot point. One exception here is the post CABG patient. We prefer to continue on IV insulin for 72 hours in CABG patients. Many CABG patients are eating by 72 hours, but patient appetite (and therefore food intake) is can be unpredictable. We prefer to have the ICU nurse count the carbs eaten and give a Novolog dose immediately after eating based on carbs actually ingested. If the patients insulin:CHO ratio is unknown, we will use a ratio of 1 unit of insulin for each 15gm of CHO ingested, given sq, in addition to the IV drip.

By giving the supplemental mealtime sq insulin, we avoid causing the IV insulin infusion rate to increase at 1 and 2 hours after eating, and avoid mild hypos 3 – 4 hours after eating.

11) Conversion from the IV protocol to subcutaneous insulin, or something else.

One unexpected consequence of the widespread adoption of IV insulin in our hospitals has been the question of ‘how do I get the patient back to subq insulin’, or “do I restart their pills”.

In fact, the endocrinologists are now rarely consulted while on IV insulin, since the surgeons and intensivists have learned to provide excellent diabetes care without an endocrinologist. Thus the majority of our consults now come at the time to stop the IV insulin. Conversion off IV insulin is not that difficult.

First, we don’t convert to subq if the patient isn’t eating, or on a ventilator. It is simply better to leave the IV insulin going until they can eat solids.

Once the diet is started, we typically convert to sq insulin unless they are a CABG patient less than 72 hours postop.

We typically calculate the estimated insulin requirement from the last 12 hours of IV insulin use, and reduce it by 20%. [Daily insulin requirement = 80% x 2 x last twelve hours of insulin]

We then give half of that insulin as Lantus (glargine) and split the remaining half among the three meals. We also use a correction dose to adjust for hyperglycemia or hypoglycemia.

Example:

Patient comes off the IV insulin drip; she used 23.6 units of insulin in the last 12 hours.

Estimated insulin requirement: $2 \times 23.6 \times 0.80 = 37.76$ or 38 units

| | | |
|-------------|---|---------------------------------|
| Lantus dose | = | 19 units |
| Breakfast | = | 6 units + correction dose |
| Lunch | = | 6 units + correction dose |
| Supper | = | 6 units + correction dose |
| Bedtime | = | correction dose if above target |
| 0200 | = | correction dose if above target |

The correction dose can be used from a table (see our subcutaneous insulin order form for this) or calculated as follows:

Correction dose = [Blood Glucose – 125] / SF

Sensitivity Factor (SF) = 1700 / Total Daily Dose

So in this example

Sensitivity Factor = $1700/38 = 44.7$ or 45

Correction dose = [Blood Glucose – 125] / 45

If the BG was currently 215 mg/dl , then

Correction dose = $[215 - 125] / 45 = 2.0$ units.

Thus in our hypothetical example, this patient with a BG of 215 would receive 8 units of insulin if it is a meal time, and 2 units if at bedtime or 0200.

If the BG was currently 80 mg/dl , then

Correction dose = $[80 - 125] / 45 = -1.0$ units (a negative number)

Thus in our hypothetical example, this patient with a BG of 80 would receive 5 units of insulin if it is a meal time, and no units if at bedtime or 0200.

Note: Calculating the Sensitivity Factor, Total Daily Dose, and setting up the Correction Dose formula is a *doctor* function. Calculating the correction dose from the doctor supplied formula is a *nursing* function. I suggest that you insure that your nursing unit is capable of doing this calculation reliably before you write the orders. Be aware that some computerized pharmacy systems will choke on these orders, and the nursing unit may receive orders that do not reflect what the doctor actually wrote. Check with your nursing staff on this first.

If these concepts seem foreign to you or if you feel the nursing units may not be able to calculate the correction dose reliably, look at our order form which has preset correction dose ranges set up.

What about conversion back to oral agents? This is possible in a small number of cases. Most of our IV insulin alumni have acquired contraindications to some or all of their oral medications during their illness. For instance, their renal function may be impaired, making metformin a poor choice; they may have volume overload, making a TZD such as Actos or Avandia contraindicated. In ischemic heart disease, there is some evidence that sulfonylureas (with the exception of Amaryl) may increase the mortality rate. If none of these problems apply, and the patient was well controlled before their illness, and is now eating well, we will consider restarting the oral agents, along with a correction dose of insulin. Often the patient leaves the hospital still on insulin, and is converted back to oral agents as appropriate as an outpatient.

A few patients require little, or no, diabetes medication postop. These may be patients who did not have 'full blown' diabetes before their illness. They probably are those with 'impaired glucose tolerance' who became hyperglycemic with the stress of their illness. The problem here is the reality that many of patients labeled as non-diabetic actually *did* have diabetes before their hospitalization; they were simply one of the 5 million undiagnosed diabetics in the US.

If you have a HbA1c from admission, this could help identify those who have normal metabolic control prior to admission. Later in the hospitalization the HbA1c is going to be less reliable because of IV fluids, recent glycemic derangements, transfusions, blood loss, etc. For patients in this group, it is a judgment call as to whether to continue treatment, or continue insulin. It is my own preference in the majority of cases to wean down (rather than stop) the basal insulin, and stop weaning if hyperglycemia appears.

12) IV insulin use outside the ICU setting

Our initial use was entirely in the ICU setting, however as the nursing staff discovered that this algorithm is effective and safe, use on regular hospital floors has become available to us. The limiting factor has been the availability of nurses trained in the method, and the frequency of fingersticks.

If we use the Atlanta protocol on the floor, we typically use higher target glucose readings for a 100 – 140 target.

The Atlanta can be used on the floor, however staffing ratios may make this difficult to implement if the patient is on hourly BG.

We have implemented a vastly different protocol of lower intensity for use in the OR, RR and on hospital floors. A variant of this protocol has been in use for a number of years at the University of Washington and is described in the literature. The advantage of this protocol is its simplicity. It will not provide control that is as tight as the Atlanta protocol, but the majority of patients have very good control and a very low incidence of hypoglycemia. The latest version is available by clicking on the link below.

A very similar protocol has been released by the Texas Diabetes Council at <http://www.dshs.state.tx.us/diabetes/PDF/algorithms/infusion.pdf> . This low intensity protocol shares most of the features of our high intensity protocol. The differences are that ours has the availability of a lower than standard insulin schedule, and our cutoff for the drip is 80 mg/dl rather than 70mg/dl. This gives us a slightly wider safety margin when used on a hospital floor, and if necessary ours has a dose schedule that will work for the occasional patient with tiny insulin requirements.

Either of these low intensity protocols provides control that is immensely better than a sliding scale approach.

Be prepared for a real battle with administration when you want to roll out IV insulin to the floors. There appears to be two types of concerns, one real, and one imaginary.

The imaginary concern is that IV insulin is inherently unsafe. I haven't met a clinician yet who could explain why an IV drip of 1.0 u/hr for 10 hours was less safe than a sq injection of 10 units. After all, if we have problems we can stop the drip, whereas the sq injection cannot be called back. The pharmacokinetic half life of insulin is only about 9 minutes, a fact that most docs, nurses, and pharmacists fail to recognize. So do your best to reassure the staff that this is *safer*.

The real concern of administrators is cost and adequate staffing. Administrators always count costs more easily than they can count savings. The extra cost for a floor IV insulin protocol is the cost of 12 BG tests a day vs 4 ~ 6 BG tests a day. We can easily measure the costs of strips, lancets, nurses, nurse aides, etc.. We

have not had to add any staffing to the floors using IV insulin. The low intensity protocol is sufficiently easy to do that it has not interfered with nursing workflow.

We are fortunate enough to have one local hospital that embraced IV insulin rapidly, and it is available on almost all floors. We initially selected two nursing areas that we felt were most in need of IV insulin and had staff capable of implementing it. In this case, we used the cardiology step down unit, and the surgical floor. A nice surprise was that we had an easier time implementing on the surgical floors, and asking for IV insulin there is now a snap.

Patient perception of the floor IV program has been extremely favorable. Many DM patients are quite worried that their DM will be neglected during their hospital stay. This is not an unreasonable fear, since they often have exactly that experience from previous hospitalizations. One family member of one of our orthopedic patients was so impressed with the smooth BG control on IV insulin that they called all their friends from the room bragging about how advanced this hospital was to use IV insulin.

13) Advocacy

It helps to have a '*physician champion*' help you implement IV insulin in your hospital. This does not have to be an endocrinologist. Many hospitals have no endocrinologist, yet have implemented successful IV insulin programs. Hospitalists, pulmonologists with intensive care expertise, internists, and family physicians with an interest in good diabetes control can help. Many times they have come from institutions that use IV insulin, or they may have attended a program that demonstrated improved outcomes with IV insulin.

If your program is physician driven, you will have a much greater chance of success than if the hospital attempts to enact the program by a royal fiat.

The best strategy for implementation will depend on your hospital, and its political structure. In our case, we began with the ICU nurse manager, showed her our planned protocol, and said "can you do this". Since she had endured innumerable permutations of insulin drip orders over the years, none of which worked that well, she instantly appreciated the potential of a standardized program that everyone could agree on. We began using each protocol during a test phase to see how well the drip performed, and how well the nursing staff could follow the instructions.

After we chose the Atlanta protocol, we expanded its use and had printed copies of the protocol available on the units for our personal use. The rank and file ICU nurses appreciated the program because a) it worked very well and b) it was standardized. Amazingly they would push other doctors to use our order pages when they mentioned starting IV insulin, and it became the de facto standard without being officially considered by the Pharmacy committee.

We were able to fine-tune the order set in order to make them easier to implement and reducing the chance of misinterpretation. This improvement phase would never had occurred if we had gone through the committee process. Furthermore, many of the people on the committees are not stakeholders in the process, and less likely to recognize problems or contribute positive comments.

Eventually we did take this to the Pharmacy committee, and they approved it as an official hospital protocol. Bear in mind that by this point 90% of the IV insulin orders were written with this protocol, so approval was a formality.

In my opinion, you will usually do best if you identify the key people who can make innovative changes in your hospital ICU. Start there, rather than with a committee. Hospital committees get bogged down with minutia, half the people there don't understand what you are doing, and it can take months or years to get off the ground. A camel is a horse designed by committee. Avoid creating another camel at your hospital.

These protocols likely don't need committee approvals in your hospital if individual doctors choose to use them. Remember that these insulin drips are doctor's orders; so have your physician champions start using the insulin drip protocol on their own to demonstrate their effectiveness. Please modify it to fit the workflow in your hospital. Doctors are legally are entitled to write IV insulin as they see fit, and the hospital is obligated to follow their orders if they are capable of competently giving IV insulin and properly monitoring the patient.

14) Computer implementation

Obviously computer based algorithms would allow even more correction factors to be used. The 'rate of change' has been included in many current IV insulin protocols. It is the 'rate of change' assessment that makes these newer protocols somewhat messy for busy ICU nurses to do. They would be great if coded into a computer, relieving the nurses from having to follow a challenging decision tree.

One of our hospitals has integrated our version of the Atlanta protocol into the nursing computer desktop at each ICU bed. This allows the nurse to simply enter the current BG. The computer displays the current multiplier, dose, and BG; the nurse compares the actual BG with target BG, adjusts the multiplier and calculates the dose. The insulin doses and BG results are plotted on a graph available on the COW at each ICU bedside.

One of the advantages of the Atlanta protocol is that it can easily and safely be implemented on paper, as well as on computer.

15) Future directions

Our focus at this point is making the process as safe and easy as possible. Although we have not had any significant hypoglycemic events to date, the acceptance of this algorithm depends upon demonstrating that this program reduces errors, improves outcomes and costs less.

This program would lend itself to a computer based algorithm that would automatically combine physician entered orders, lab results obtained at point of care, and provide an automatic recommendation for the nurse to use in adjusting the insulin drip rate. A local surgeon has already written a C++ program to help nurses calculate the drip rates. It is my understanding that the Glucomander program uses an algorithm similar to the Atlanta protocol.

Furthermore, as non-invasive BG methodology becomes available, it would be logical for the IV insulin pump to be controlled by the BG sensor. We would still have the issue of setting the insulin sensitivity parameter (the *multiplier*), and appropriate alarms to turn off insulin or warn the nursing staff of problems. We have used the VIA glucose monitor in the past, and found that the amount of nursing time spent maintaining the unit was significantly higher than expected.

Recently the Dexcom continuous BG meter was approved, and interestingly has approval for hospital use. These are wonderful devices to see glucose trends with, but in my opinion are not accurate enough to use with an IV insulin program.

16) On Google ?? Really ??

I am getting many calls, requesting a copy of the protocol. I didn't realize that Google would pick up this page, since it was intended to be used only from within our hospitals locally. I am thrilled that there is wide interest in the IV insulin protocols. The location of the protocol and associated material is located at www.amarillomed.com/diabetes/hospform.htm

We find the flow sheet to be indispensable, and the example flow sheet is useful when training nurses unfamiliar with the protocol. All of these forms are in Acrobat format.

Again, the credit for the Atlanta protocol goes to Dr. Bode & his group. All we did was polish up the orders and locate them in a place that people could find.

Good luck with implementing IV insulin in your hospital.

17) Questions and Comments are appreciated.

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