Catheter Obstruction With Continuous Subcutaneous Insulin Infusion

Effect of Insulin Concentration

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The most precise way to mimic normal insulin secretion is with continuous subcutaneous insulin infusion (CSII; 1). Although CSII is just one of several regimens that may be used for implementation of intensive insulin therapy, it may offer real advantages in terms of pharmacokinetics of insulin delivery (2). Because CSII remains an important option for patients attempting meticulous glycemic control, it is important to continue to examine the potential complications of these devises. For example, although the use of buffered insulin has greatly decreased the frequency of occlusions (3), unexplained hyperglycemia that is corrected by infusion set change continues to be a problem for insulin pump users. We hypothesized that insulin aggregation and occlusion would occur less often if the flow rate of insulin solution was greater through the infusion set. To test this hypothesis, we studied 10 patients using CSII and examined occlusion rates with two different concentrations of insulin.

Ten patients with insulin-dependent diabetes mellitus (IDDM) were recruited from the diabetes registry at the Washington University School of Medicine. Only patients who had been using CSII continually for a minimum of 1 yr were asked to participate. All patients were using a MiniMed infusion pump (Sylmar, CA) and were provided with 107 cm Polyfin (MiniMed, Sylmar, CA) infusion sets with bent needle. Only the abdomen was used as an infusion site and patients were provided with and instructed to use only buffered purified pork-soluble insulin (Velosulin, Nordisk, Gentofe, Denmark). The dilution medium for this insulin contains m-cresol, glycerol, and sodium phosphate. Infusion sets and syringes were replaced every 48 h.

The protocol was begun by randomizing the patients administering either U-40 or U-100 soluble insulin. After 12 wk, each patient alternated to the other insulin concentration. The protocol was completed after 12 additional wk on the second insulin concentration.

For all 6 mo of the protocol, patients were asked to continue their usual basal insulin rate and bolus algorithms. Participants were asked to measure capillary blood glucose levels before meals and at bedtime. For any blood glucose level (not explainable by dietary indiscretion) >13.9 mM, patients were instructed to bolus (administer) the predetermined insulin dose based on their individual algorithms. If the subsequent blood glucose concentration still exceeded this level and there was no obvious etiology for the hyperglycemia, the patient was instructed to remove the needle and observe insulin flow with a bolus of 3 U. An occlusion was documented by the subject only when insulin flow was completely obstructed. An occlusion also was documented when the infusion pump alarm system for occlusion was activated and flow was noted to be impaired.

The mean ± SD patients' age, duration of IDDM, and duration of previous CSII use were 35.1 ± 7.3, 16.4 ± 8.1, and 3.7 ± 2.3 yr, respectively. Two patients reported occlusions during the 12-wk interval with U-40 insulin for a total of three occlusions. Six patients reported occlusion with the U-100 insulin for a total of 20 occlusions. Occlusion occurred more frequently with the U-100 compared with the U-40 insulin (0.79 ± 0.30 vs. 0.10 ± 0.07 occlusions/patient/mo, $P < 0.05$). There was no relationship between the basal rate or total dose of insulin infused and occlusion rate. Only 2 of 23 (8.7%) occlusions that occurred during the 6 mo of the study were associated with activation of the pump alarm system. No one observed insulin leakage from the catheter. One patient experienced two episodes of diabetic ketoacidosis (DKA) caused by occlusions during the U-100 period. There were no episodes of DKA during the U-40 period for any of the study subjects. There also were no episodes of severe hypoglycemia (requiring the assistance of another person) in any of the subjects during the study period.

Although infection and patient (or provider) inexperience are potential etiologies for hyperglycemia and DKA in

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patients who use CSII, accidental cessation of insulin is the most common cause of this complication. Catheter leakage and pump failure are other potential causes of interrupted insulin delivery, but were not observed during the study. We attribute this fact to improvements in infusion pumps and catheters.

Although buffered-soluble insulin reduces the frequency of catheter occlusions, we believe that this was still a common problem in our patients. Indeed, 6 of 10 of our patients experienced at least one catheter occlusion during the U-100 period. We could not determine any distinguishing features in these six patients because they did not differ with the other patients in terms of type or dose of insulin infused or location of the catheter needle. By diluting the insulin to the U-40 concentration, we have shown a significant reduction in the rate of occlusions. One possibility is that the flow rate per se was not the etiology to our finding but rather the increased residence time of insulin in the syringe and catheter-promoted increased insulin aggregation. On the other hand, a type 2 error probably contributes to our inability to document a relationship between the insulin dose (basal or total) and occlusion rate. Thus, we cannot rule out that the large increase in flow rate with U-40 insulin (150%) is at least partly responsible for our finding.

What is of concern is that only 8.7% of catheter occlusions resulted in activation of the pump alarm system. We find it unlikely that any of the catheter occlusions were actually misrepresentations of other metabolic derangements in these experienced CSII users. Until further improvements are made with this safety feature of CSII, patients need to be suspicious of obstruction when unexplained hyperglycemia occurs.

Catheter occlusions remain a significant complication of CSII. Perhaps the development of new insulins or catheters will minimize this problem (4). Nevertheless, it would be prudent for patients and providers to be prepared for the occurrence of catheter occlusions. Dilution of the insulin to U-40 may help to alleviate flow obstruction in some patients.

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