The Importance of Intensive Supervision in Determining the Efficacy of Insulin Pump Therapy

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The role of intensive supervision in the success of insulin pump programs was examined in six type I diabetic subjects utilizing a crossover protocol. The highly motivated volunteers who had attained euglycemia during intensive supervision had a significant increase in plasma glucose and hemoglobin A_{1c} concentrations during the period when supervision by the medical team and frequency of self blood glucose monitoring decreased. Intensive supervision is a critical feature in ensuring maximal efficacy of insulin pump therapy. The importance of such supervision may be even greater in less motivated and adherent patients. DIABETES CARE 6: 295–297, MAY–JUNE 1983.

Insulin therapy with external programmable pumps in type I diabetic patients has been successful in achieving euglycemia in regimented inpatient and long-term outpatient studies.[1–3] The efficacy and safety of pump therapy has been established in the carefully supervised and structured research setting. Recently, the Mason Clinic has presented its results with the insulin pump in a carefully structured nonresearch setting.[4] Whether the success of continuous subcutaneous insulin infusion (CSII) is due to the pump itself or is more a function of the close supervision, dietary training, and self blood glucose monitoring has not been formally studied. In order to examine the role of intensive supervision in the success of CSII regimens, a crossover study between intensive supervision and "loose" supervision of pump therapy was employed.

METHODS

Six type I diabetic subjects who had achieved near-normal blood glucose control for at least 4 mo during a research protocol were recruited for the study. The six patients were selected for their high degree of motivation and medical sophistication. The group included a physician, nurse, and two biomedical technicians.

Intensive supervision. During the research protocol (intensive supervision), individual algorithms for insulin delivery with the external pump (Auto-syringe AS-6C, Auto-syringe, Inc., Hooksett, New Hampshire) were formulated with the use of hourly blood glucose monitoring in a metabolic research ward [General Clinical Research Center (GCRC)] as previously described.[5] The mean hospital stay was 5 days, and the subjects received daily instruction from the physician, research nurses, and dietitians in self blood glucose monitoring, exercise, diet, and appropriate adjustment of pump therapy. After the patients had achieved the blood glucose goals of fasting blood glucose < 100 mg/dl, 2-h postprandial < 170 mg/dl, and no episodes of hypoglycemia requiring assistance, they were discharged from the GCRC. Outpatient follow-up included daily phone contact and weekly visits with the physician until blood glucose control monitored with a reflectance meter (Dextrometer, Ames Company, Elkhart, Indiana) 4–6 times per day was achieved. The goals for outpatient therapy were the same as inpatient therapy. In addition to premeal monitoring, patients were expected to check 2-h postprandial results several times per day. After outpatient goals were met, weekly phone contact and monthly physician visits were used to review blood glucose results and individually adjust the insulin delivery algorithms. Self blood glucose monitoring (SBGM) was performed four times daily with one-half of the measurement performed 2 h postprandial. Twenty-four-hour urine glucose and hemoglobin A_{1c} concentrations were measured every 6 wk throughout the study. A diary that recorded blood glucose results, hypoglycemic reactions, and insulin pump adjustments was kept by all subjects.

Loose supervision. After at least 4 mo of intensive supervision and hemoglobin A_{1c} results in the normal range, subjects were instructed to continue performing blood glucose measurements as often as they felt necessary to maintain satisfactory control. No particular frequency of SBGM was stipulated. Routine physician visits were every 3 mo and

phone contact was no longer encouraged except for emergencies.

After at least 4 mo of loose supervision, all of the subjects were restarted on the intensive supervision regimen for a period of a least 4 mo.

Hemoglobin A_{1c} was assayed with a high-pressure liquid chromatography (HPLC) method. The labile fraction was eliminated by preincubating samples in isotonic saline at 22°C for 14 h.[6] The mean for nondiabetic individuals (N = 100) is 5.04 ± 0.67% (1 SD) and the interassay coefficient of variation is < 3% for both diabetic and nondiabetic individuals.

RESULTS

The six subjects achieved the outpatient blood glucose goals within 2–3 wk of the intensive supervision regimen. Mean blood glucose concentrations (from SBGM) were in the near-normal range, repeated 24-h urine collections were free of glucose, and hemoglobin A_{1c} concentrations decreased into the normal range (Table 1). The frequency of home blood glucose monitoring was variable. Hypoglycemic reactions, defined as the occurrence of typical symptoms and/or a blood glucose < 60 mg/dl, were infrequent and symptomatically mild. There was only one episode of hypoglycemia requiring assistance by a patient's husband.

The crossover to loose supervision resulted in a significant increase in hemoglobin A_{1c} concentration and mean plasma glucose in all subjects. Although no glycosuria was noted in the intensive supervision period, 69% of the 24-h collections were glycosuric during the loose supervision period. The frequency of SBGM decreased in all subjects. The frequency of hypoglycemic reactions was not significantly different during the loose supervision periods.

The crossover back to intensive supervision was associated with a decrease in all the indices of metabolic control. There were no significant complications of pump therapy during any phase of the study.

DISCUSSION

The much publicized success of insulin pump therapy in normalizing metabolic control in type I diabetes has been accomplished in highly structured, supervised settings. The infusion device itself is only a small part of the overall program that routinely accompanies intensive therapy. Several studies have documented statistically similar levels[7,8] or only somewhat higher levels[5] of blood glucose control in subjects treated intensively with multiple daily injections of insulin (MDI) compared with pump therapy. The role of the intensive supervision by medical personnel and the importance of frequent feedback with SBGM and the overall structure of the pump programs must be defined.

The current study demonstrates that a carefully structured and supervised program is essential in obtaining maximal benefit from insulin pumps. Even in the highly motivated patient group studied here, a decrease in input from the medical team led to decreased SBGM and increased blood glucose and hemoglobin A_{1c} concentrations. Based on repeated dietary histories, there was no significant change in dietary patterns over the course of the study. During the loose supervision protocol, the major change in pump therapy appeared to be that premeal doses were estimated by the patient on the basis of past experience rather than adjustment on the basis of SBGM results.

A recent study of Schiffrin and Belmonte[9] used a similar crossover design to study the importance of multiple daily self blood glucose monitoring in achieving near-normal glycemia in a group of insulin-dependent diabetic subjects using insulin pump and/or multiple daily-injections therapy. In that study, subjects were allowed to monitor their blood glucose as often as they considered necessary and were then divided into groups depending on whether they monitored

TABLE 1
Mean blood glucose, urine glucose, and hemoglobin A_{1c} values for the two protocols

	Intensive supervision 1				Loose supervision				Intensive supervision 2			
	Urine glucose* (g/24 h)	BG† (mg/dl)	A_{1c}‡ (%)	SBGM (day)	Urine glucose (g/24 h)	BG (mg/dl)	A_{1c} (%)	SBGM (day)	Urine glucose (g/24 h)	BG (mg/dl)	A_{1c} (%)	SBGM (day)
1.	0	103	5.3	3.8	2.6	136	6.5	1	6	110	5.6	4
2.	0	96	5.3	2.4	2.4		6.7	<1	0	99	5.6	4
3.	0	120	6.2	4.5	7.5	140	7.1	1.5	0	120	5.9	3.8
4.	0	111	5.8	4.8	0	113	6.2	3	0	106	5.3	4.6
5.	0	109	5.7	3.5	1.8	146	6.6	2	0	136	6.6	3
6.	0	113	6.1	4	0	140	7.4	3	0	120	6.0	4
Mean (± SE)	0	109 (1.4)	5.7 (0.06)	3.8 (0.14)	2.4§ (0.46)	135§ (2.6)	6.75§ (0.07)	1.9§ (0.15)	1.0 (0.4)	115 (2.2)	5.8 (0.08)	3.9 (0.09)

*Urine glucose: mean of 24-h collections for glucose performed every 6–8 wk.
†Mean blood glucose based on SBGM.
‡Hemoglobin A_{1c}: mean of at least three values obtained every 6–8 wk.
§Significantly different than intensive supervision period 1 and 2 ($P < 0.05$), Student's two-tailed t test.

blood glucose twice daily or more than four times daily. After 6 mo, the two groups were crossed over to either more intensive or less intensive blood glucose monitoring, respectively. Whether the degree of dietary adherence, number of office visits, or compliance with other aspects of pump therapy was different in these two self-selected groups was not noted. However, more intensive monitoring was associated with lower mean blood glucose and hemoglobin A_1 concentrations in both groups. Although both the Schiffrin study and the current study indicate an association between decreased blood glucose monitoring and higher blood glucose and glycosylated hemoglobin concentrations, neither study was able to quantitate the contribution of the other aspects of intensive supervision to the success of pump or MDI therapy.

It should be noted that the group of subjects studied here was highly selected and does not represent the average type I diabetic patient. Even during the loose supervision period, the subjects continued to have lower hemoglobin A_{1c} concentrations than the vast majority of our conventionally treated type I population. Whether a less selected population would have done as well during any phase of the study is questionable. A less adherent group of patients might have had a greater number of significant hypoglycemic reactions in the absence of frequent SBGM.

It seems clear that insulin pump therapy must be supervised in a rigorously structured manner in order for it to be most effective in achieving near-normal and safe blood glucose control. When such control has been attempted in a nonresearch setting, such as the Mason Clinic, great care has been taken to provide intensive supervision and follow-up. Unfortunately, the published data from both research and clinical centers reflect a relatively brief period of pump experience. One might anticipate that as patients use pumps for longer periods of time and the initial enthusiasm for the new devices fades, the continued reinforcement and supervision by the medical team will take on an even more important role in ensuring adherence and safety and in promoting the success of these devices.

ACKNOWLEDGMENTS: The author thanks Dr. W. Tamborlane for his advice, Katherine Hurxthal and the nursing staff of the General Clinical Research Center for their efforts, and Martha Chambers for preparing the manuscript.

This research was supported in part by grants from the Murial McLauthlin Fund, Massachusetts General Hospital, and the General Clinical Research Center, RR01066, from the National Institutes of Health. Dr. Nathan is the Capps Scholar of Harvard University.

This work was presented in part at the Toronto International Workshop on Insulin and Portable Delivery Systems, June 9, 1982.

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