

CONTINUOUS SUBCUTANEOUS INSULIN INFUSION (INSULIN PUMP) THERAPY CAN BE SAFELY USED IN THE HOSPITAL IN SELECT PATIENTS

Rachel M. Bailon, MD¹; Brenda J. Partlow, MSN, FNP-C²;
Victoria Miller-Cage, MS, FNP³; Mary E. Boyle, CNP, CDE²; Janna C. Castro, BS⁴;
Peggy B. Bourgeois, APRN, MN, CDE⁵; Curtiss B. Cook, MD²

ABSTRACT

Objective: To analyze data on inpatient insulin pump use and examine staff compliance with hospital procedures, glycemic control, and safety.

Methods: We conducted a retrospective review of charts and bedside glucose data for patients who had been receiving outpatient insulin pump therapy and were admitted to our teaching hospital between November 1, 2005, and February 8, 2008.

Results: During the study period, there were 50 hospitalizations involving 35 patients who had been receiving outpatient insulin pump therapy. The mean age and duration of diabetes of the 35 patients was 55 years and 32 years, respectively. Sixty-six percent were women, and 91% had type 1 diabetes. Patients in 31 of the hospitalizations (62%) were deemed candidates for continued insulin pump therapy during their stay. Of the 31 hospitalizations, 80% had the presence of the pump documented at admission; 100% had an admission glucose value; 77% had documentation of signed patient consent; 81% had evidence of completed preprinted insulin pump orders; 77% received an endocrine consultation; and 68% had a completed bedside flow sheet. Patients continuing insulin pump therapy had mean bedside glucose levels similar to those whose pump therapy was discontinued ($P = .11$); however, the proportion of hypoglycemic events was lower among insulin pump users ($P < .01$) than among nonusers.

Conclusions: Insulin pump therapy is safe for select inpatients. Overall, staff compliance with procedures was high, although we identified areas for improvement. Continued study is needed on the effectiveness of insulin pump therapy in controlling inpatient hyperglycemia. (Endocr Pract. 2009;15:24-29)

Abbreviations:

BedGluc = bedside glucose average; **CPOE** = computerized physician order entry; **CSII** = continuous subcutaneous insulin infusion; **HbA_{1c}** = hemoglobin A_{1c}

INTRODUCTION

Outpatient continuous subcutaneous insulin infusion (CSII), commonly referred to as insulin pump therapy, delivers intensive insulin treatment for optimal glucose control. As the use of CSII increases, health care providers in the hospital may more frequently face the issue of how best to manage the care of patients who are using CSII. Many individuals on CSII therapy are educated extensively in the self-management of diabetes mellitus and can invest considerable time and money in the technology. Consequently, when they are admitted to the hospital, patients receiving CSII often do not wish to surrender their insulin pumps or their diabetes management to the hospital staff.

We previously published suggestions to assist practitioners with the management of CSII in the hospital (1). These recommendations were developed in response to a lack of published guidelines on how to manage treatment for patients on CSII therapy after admission. The objectives of our inpatient guidelines were to promote patients' independent use of their insulin pumps during hospitalization and to maximize the safety of patients (1). The policy promotes a collaborative relationship between the hospital staff and patients on CSII. An analysis of a smaller number of hospitalizations than that in the present report indicated that CSII could be safely continued in the hospital (2). In

Submitted for publication July 31, 2008

Accepted for publication September 5, 2008

From the ¹Department of Internal Medicine, ²Division of Endocrinology, ³Nursing Administration, and ⁴Division of Information Technology, Mayo Clinic, Scottsdale, Arizona; and ⁵PBB Associates, LLC, Baton Rouge, Louisiana.

Address correspondence and reprint requests to Dr. Curtiss B. Cook, Division of Endocrinology, Mayo Clinic, 13400 East Shea Boulevard, Scottsdale, AZ 85259. E-mail: cook.curtiss@mayo.edu.

© 2009 AACE.

this report, we review a greater number of hospital cases to expand our analysis of inpatient CSII use, with particular focus on assessing the staff's compliance with our inpatient insulin pump policy, examining data on glycemic control, and reviewing safety of use.

METHODS

Description of Facility

Our tertiary care academic medical center is a 200-plus-bed facility in metropolitan Phoenix, Arizona. All general medical and surgical specialties for adult patients are represented; pediatric care and obstetric care are not provided. The hospital also has a level II trauma center and an inpatient rehabilitation unit. Inpatient care is provided by various types of practitioners, including resident physicians, students in allied health and medical school, physician assistants, nurse practitioners, and staff physicians.

Summary of Insulin Pump Policy

We adapted our inpatient CSII guidelines (1) to create a formal policy. Both the guidelines and the policy consist of 3 basic components: (a) a list of suggested contraindications (eg, patient with altered state of consciousness, critically ill patient, patient at risk of suicide, other reason deemed appropriate by physician) for continued insulin pump use in the hospital; (b) a set of rules to guide the medical staff in insulin pump management after patient admission; and (c) a requirement for signed informed consent from the patient that details the conditions for continued use of CSII in the hospital (Box 1) (1,2). Patients are required to provide their own insulin pump supplies (eg, infusion sets and catheters) because it is not practical for our facility to stock items from various pump manufacturers. Patients were switched to subcutaneous insulin therapy if their CSII therapy was discontinued in the hospital.

In our previous publication (1), we proposed metrics to evaluate the results of our policy and to evaluate the outcomes of inpatient insulin pump use. These metrics included age, sex, diabetes duration, length of stay, pump-related adverse events, proportion of consent forms signed by the patient, use of preprinted order sets and bedside flow sheets, and data on glucose control.

Patient Definitions

All patients receiving outpatient CSII admitted to our hospital for 24 or more hours were eligible for chart review. Some patients had multiple admissions. Each hospitalization was considered an independent opportunity to implement our inpatient insulin pump policy. Hence, the unit of analysis for this study was the hospital case rather than the individual patient. We stratified hospital cases into 2 groups: patients who remained on CSII therapy throughout their hospital stay ("pump on" patients) and patients whose CSII therapy was discontinued at admission ("pump

off" patients). If CSII therapy was temporarily discontinued for a surgical procedure, then restarted and maintained for the duration of the hospitalization, we considered these patients as having continued CSII therapy during the hospital stay.

Extraction of Glucose Data

We retrieved data on capillary (bedside) glucose values by linking patient identifiers to our electronic laboratory database. Bedside glucose monitoring is conducted with an instrument that scans and records patient identification from a bar code, followed by direct downloading to our laboratory database. Commercial software (Medical Automation Systems, Charlottesville, Virginia) facilitates the interfacing of glucometer data with the electronic laboratory file. In early 2007, our hospital instituted a requirement for a hemoglobin A_{1c} (HbA_{1c}) measurement at admission if one had not been done on the diabetes patient within the preceding 60 days (3). This new policy was introduced to ensure compliance with recent guidelines for certification in disease-specific care regarding diabetes that were established by The Joint Commission, formerly JCAHO (Joint Commission on the Accreditation of Healthcare Organizations) (3). We recorded and analyzed available HbA_{1c} values anytime during the 60 days before admission through day 7 of the hospitalization.

Data Analysis

Demographics (age, sex, race or ethnicity, reason for admission, and length of hospital stay) were abstracted from the electronic medical record; for patients with multiple admissions, we used the age at the most recent admission. We recorded available data on type of diabetes, duration of diabetes, and length of time that the patient reported being on CSII therapy. We also determined staff compliance with major policy components by reviewing the nursing staff's documentation of the presence of the pump at the time of admission, measurement of admission glucose level, presence of a signed patient consent form, evidence of completed preprinted insulin pump orders, requests for endocrine consultation, and documentation of completed bedside flow sheets.

Our facility made a gradual transition from paper orders to computerized physician order entry (CPOE) in 2007. Written insulin pump orders were gradually migrated into the CPOE system throughout the year, and the CPOE format corresponded with the outlay and content of the written orders. Thus, for this analysis, an insulin pump order was considered to be present in the record if it was a completed CPOE or an electronic document that had been scanned from its original written version into our electronic medical record.

We assessed glycemic control by using bedside glucose data as previously described (4,5). Bedside glucose measurements for the entire length of stay were averaged

for each patient, and the composite bedside glucose average (BedGluc_{avg}) was calculated (4,5). The prevalence of hypoglycemia (at least 1 measurement <70 mg/dL) and hyperglycemia (at least 1 measurement >200 mg/dL) was determined. The percentage of hypoglycemic values (bedside glucose <70, <60, <50, and <40 mg/dL) and hyperglycemic values (bedside glucose >200, >250, >300, >350, and >400 mg/dL) was calculated for different cutpoints by counting the number of these events for each patient, dividing by the total number of per patient bedside measurements, and then multiplying by 100 (4,5). This method allowed adjustment for different measurements across the study's patient population and captured information on multiple episodes of hypoglycemia or hyperglycemia in individual patients (6).

We compared the glucose control measurements of "pump on" and "pump off" patients. Data are reported as mean \pm standard deviation where applicable. Statistical differences between continuous variables were tested using the Mann-Whitney test, and differences between categorical variables were tested using the χ^2 test.

RESULTS

Patient Characteristics

We identified a total of 50 hospital admissions that occurred between November 1, 2005, and February 8, 2008, for 35 individual patients who had been receiving outpatient insulin pump therapy. Eight unique patients had a total of 23 admissions. Twenty-one patients were receiving their outpatient diabetes care outside of our health system. The mean age of the 35 patients was 55 years; the mean diabetes duration was 32 years. The mean self-reported duration of CSII therapy was 4 years. All patients were white, 66% were women, and 91% were identified in their medical records as having type 1 diabetes; documentation of diabetes type was not available for 1 patient. Most patients were admitted for an acute problem (eg, emesis, fever, positive stress test requiring urgent coronary artery-bypass grafting, or cellulitis). During 2 hospitalizations in different patients, CSII was temporarily discontinued for surgery, but therapy was reinstated after discharge from the recovery area. Otherwise, patients who were allowed to stay on CSII at admission remained on therapy throughout the hospital stay.

The staff deemed that continuing CSII therapy in the hospital was safe in 31 of the 50 hospitalizations (62%). "Pump on" patients had a significantly ($P = .003$) shorter length of stay (3 ± 2 days) than "pump off" patients (7 ± 7 days); 42% of "pump on" patients were hospitalized for only 1 day. Among the 8 unique patients who had readmissions, pump therapy was continued during 14 hospitalizations and discontinued in 9; that is, the same patient may have been deemed a candidate for continued therapy during 1 admission, but not during another. Reasons for

pump disconnection at admission were varied and included factors such as the patient not having access to personal insulin pump supplies, not being familiar with the use of the pump, having made a suicide attempt, having a pump that malfunctioned, having altered mental status, or having diabetic ketoacidosis. CSII therapy was discontinued in all clinical situations where inpatient use was contraindicated per our policy. Most "pump off" patients received alternate therapy (eg, basal and short-acting insulin) after cessation of CSII therapy.

Adherence to Postadmission Procedures

Initial nursing assessments noted the presence of the insulin pump in 81% of the "pump on" cases, the brand of the pump in 100%, and the type of insulin being infused in 100% (Table 1). All patients had a glucose checked at admission. Noted in the medical records of 77% of "pump on" patients was the presence of a written consent form that detailed conditions for continuing CSII therapy in the hospital, and the completed preprinted order set was found in the documentation of 81%. An endocrinology consultation was requested for 77% of "pump on" cases (vs 94% of "pump off" cases, $P = .11$), and the bedside flow sheet was found in 68%. No adverse events (eg, pump site infections) were reported for the patients who continued CSII therapy.

Glycemic Control

BedGluc_{avg} values were comparable ($P = .11$) between "pump on" (BedGluc_{avg} = 197 ± 61 mg/dL) and "pump off" patients (BedGluc_{avg} = 172 ± 32 mg/dL). There were 25 "pump on" and "pump off" patients with HbA_{1c} values that had been analyzed according to selection criteria. One patient had 3 hospitalizations over a 6-week period, so we included only the HbA_{1c} level that was obtained before the first hospitalization. The mean \pm standard deviation HbA_{1c} value for the 25 hospitalizations was $8.1 \pm 1.4\%$, and the mean interval between measurement and admission was 7 ± 12 days (range, 32 days before admission to 6 days after admission). No difference ($P = .13$) in mean HbA_{1c} level was found between "pump on" (HbA_{1c} = 7.7%, $n = 17$) and "pump off" patients (HbA_{1c} = 8.9%, $n = 8$).

In "pump on" patients, the prevalence of hypoglycemia was far lower than that of hyperglycemia: 35% of "pump on" patients had at least 1 bedside glucose value that was less than 70 mg/dL, but 84% had at least 1 bedside glucose value greater than 200 mg/dL (Fig. 1). For "pump off" patients, 84% had hypoglycemia and 94% had hyperglycemia (Fig. 1). The percentage of patients with hyperglycemia was similar between "pump on" and "pump off" patients ($P = .25$) (Fig. 1, Panel A), but "pump on" patients had significantly less hypoglycemia ($P < .01$) than "pump off" patients (Fig. 1, Panel B).

Among "pump on" patients, the per person percentage of hyperglycemic events was low (Fig. 2, Panel A)

Box 1. Current Procedures for Patients Admitted to the Hospital While on Continuous Subcutaneous Insulin Infusion Therapy (CSII)

Presence of insulin pump, brand of pump, and insulin type are identified.
 Blood or capillary glucose level is determined.
 Contraindications for continued use of insulin pump are assessed.
 Physician order for alternate insulin therapy is obtained if CSII must be discontinued.
 Patient's consent for CSII is obtained.
 Admitting physician writes initial order for insulin pump therapy using the preprinted order form.
 Endocrinology, diabetes education, and nutrition consultations are ordered by the admitting physician.
 Insulin pump basal-bolus blood glucose record flow sheet is placed at the patient's bedside.

Table 1
Adherence to Hospital Insulin Pump Policy When Continuous Subcutaneous Insulin Infusion Therapy Was Continued After Admission in 31 Hospitalizations

Documentation of policy component	Patients	
	No.	%
Recognition of patient's insulin pump by the nursing staff	25	81
Brand of pump	31	100
Type of insulin in pump	31	100
Glucose reading at admission	31	100
Consent of patient	24	77
Use of preprinted insulin pump order form	25	81
Endocrinology or diabetes education team	24	77
Presence of bedside flow sheet	21	68

compared with the per person percentage of hyperglycemic events (Fig. 2, Panel B). Similarly, among "pump off" patients, the per person frequency of hypoglycemic events (Fig. 3, Panel A) was also low compared with the per person frequency of hyperglycemic events (Fig. 3, Panel B). Compared with "pump on" patients, "pump off" patients had significantly ($P < .04$) more occurrences of glucose values that were less than 70 and 60 mg/dL.

DISCUSSION

Patients who receive CSII therapy are educated intensively on diabetes self-management and invest considerable time in mastering the technology. We have often encountered situations in which patients on outpatient CSII therapy are eager to continue this treatment while hospitalized. However, there are many different insulin pump

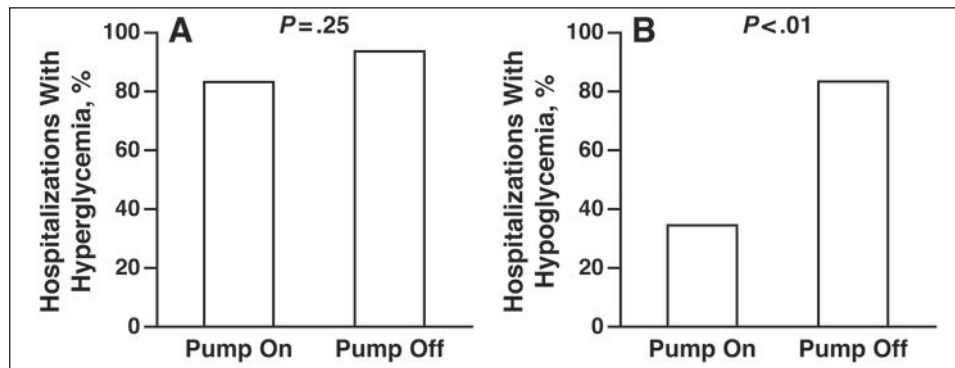


Fig. 1. Comparison of the prevalence of hyperglycemia (Panel A) and hypoglycemia (Panel B) in hospitalized patients according to inpatient insulin pump status. "Pump on" indicates patients who remained on continuous subcutaneous insulin infusion therapy throughout their hospital stay. "Pump off" indicates patients whose continuous subcutaneous insulin infusion therapy was discontinued at admission.

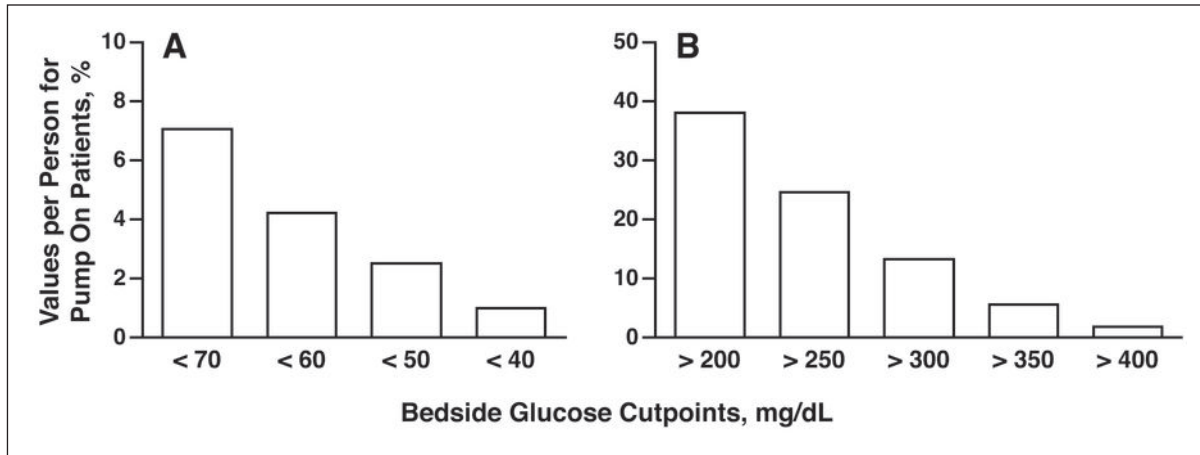


Fig. 2. Per person frequency of hypoglycemic values (*Panel A*) and hyperglycemic values (*Panel B*) according to different cutoff points for patients remaining on insulin pump therapy (“pump on” patients) after hospital admission.

models available, and given the infrequency of seeing patients who use an insulin pump, practitioners in hospitals cannot be expected to gain expertise with the technology. Although the number of patients admitted to the hospital while on CSII therapy is typically low (as seen in our analysis), when these admissions do occur, their presence will be highly visible to staff members. In addition, the potential for errors in the hospital treatment of these patients is likely to be considerable without a standardized approach to the assessment and management of their insulin pumps.

With the above considerations, we developed guidelines and a written policy to guide hospital personnel and patients on the continued use of CSII in the hospital (1,2). The analysis reported here was conducted to determine how well the hospital staff implemented the guidelines that we published previously and also to give further insight into the characteristics and glycemic control of inpatients who remained on CSII therapy. We found that most of the

hospitalized patients admitted with an insulin pump could continue CSII during their stay. No adverse events (eg, site infections or mechanical failure) occurred among those who remained on CSII.

There appeared to be appropriate selection of patients for continued insulin pump therapy during hospitalization. Overall institutional compliance with the admission and postadmission insulin pump procedures was high. In some instances, required elements were missing (eg, the consent form or bedside flow sheet); however, we were unable to determine whether they were missing because staff members did not comply with necessary procedures or because documents were not scanned into the electronic medical record.

We have conducted ongoing education of nursing staff and other providers in our hospital (ie, nurse practitioners, physician assistants, and resident physicians) about the use of inpatient insulin pumps and our institutional policies and procedures. However, there is constant staff turnover,

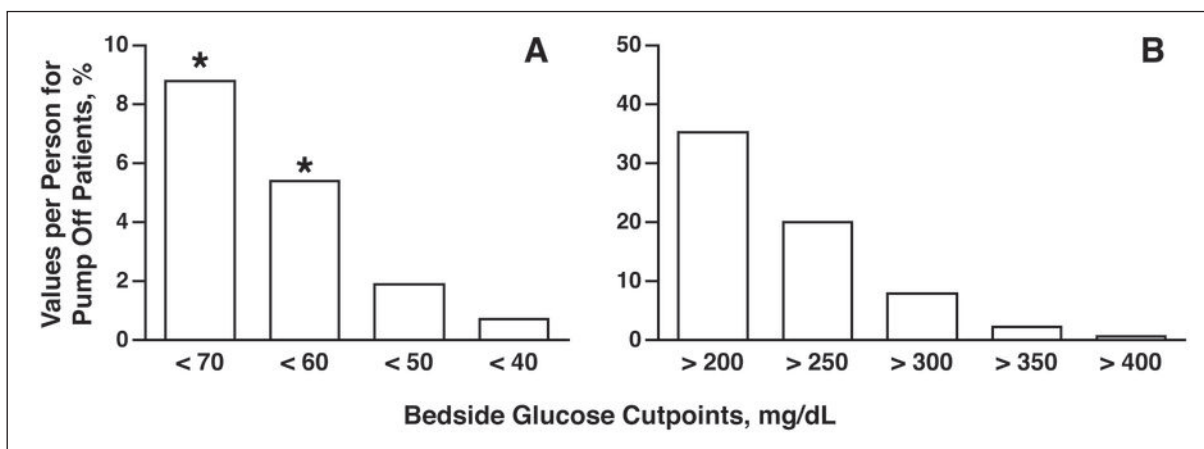


Fig. 3. Per person frequency of hypoglycemic values (*Panel A*) and hyperglycemic values (*Panel B*) according to different cutoff points for patients who discontinued insulin pump therapy at hospital admission (“pump off” patients). Asterisks denote significant differences ($P < .04$) in frequencies between “pump on” and “pump off” patients.

and familiarization with the policy may never be 100% at all times within the institution. Therefore, some noncompliance with the procedures might be expected.

Current data indicate that inpatient hyperglycemia results in poorer outcomes (7,8). Our analysis does raise a question about how effective CSII is in managing inpatient hyperglycemia. The frequency of hypoglycemia and hyperglycemia among inpatients remaining on insulin pump therapy was greater than the frequency in our general population of noncritically ill hospitalized patients with diabetes (4,5). A direct comparison of these populations is difficult because most of the patients on pump therapy had type 1 diabetes, whereas the general diabetes population in the hospital likely has type 2 diabetes (the most common form of the disease). Consistent with what we have found in the general population of inpatients with diabetes (4,5,9), the frequency of hypoglycemic episodes is far lower than that of hyperglycemic episodes, which indicates that hyperglycemia remains the bigger problem in the hospital. However, if CSII is eventually determined to be ineffective in achieving good glucose control in the hospital, this may become a contraindication to continue therapy, and all patients admitted on insulin pumps may need to be cared for with an alternative insulin regimen.

Although average glucose levels were comparable between patients who continued to use CSII and patients who had to discontinue it, our data suggest that use of the pump may have offered some advantage by limiting hypoglycemic episodes. Compared with their counterparts in the analysis, "pump on" patients experienced fewer and less frequent hypoglycemic episodes. This observation is possibly due to less severe illness, which allowed them to stay on CSII at admission, or to more stable nutritional patterns. Hence, it cannot be definitely concluded that insulin pump therapy in the hospital offers an advantage regarding hypoglycemia.

Because of the low volume of inpatients on CSII therapy, long accrual times would be required for a randomized controlled trial to answer the question of the efficacy of CSII in the hospital. Additionally, a randomized controlled trial would require some patients to remain on CSII therapy while others would be switched to a basal-bolus insulin program, and patients using CSII may not accept this protocol. In such a study, masking treatment assignments would also be difficult. Investigators of future research will also need to consider the type of diabetes, duration of diabetes, severity of diabetes complications, acuity of illness, use of medications that affect glucose control, and effect of rapidly changing dietary intake, all of which may factor into how effective CSII can be in controlling hyperglycemia in the hospital environment.

One challenge we faced during 2007 in the continued implementation of our inpatient insulin pump policy was our institutional transition to CPOE. The transition to CPOE required migration of the preprinted insulin pump

order set from a paper format to the electronic platform. This transfer of the written insulin pump order set to the CPOE environment did not seem to result in any failures of the policy or lack of implementation of the orders, although ongoing training will be needed to continue to familiarize staff members with the principles of the insulin pump procedures and with how to place an insulin pump order using the CPOE system.

CONCLUSION

We conclude that CSII therapy can be safely continued in a hospital setting in select patients. Overall implementation of our inpatient insulin pump policy has been successful. The necessary documentation and procedures are being accomplished for most patients, although improvement is needed to reach 100% compliance in performance of all components. Our analysis also provided us with ongoing data about the characteristics of the inpatient population that receives CSII. Determining whether CSII is an effective means to control hyperglycemia in the hospital will require ongoing investigation.

DISCLOSURE

The authors have no conflicts of interest to disclose.

REFERENCES

1. **Cook CB, Boyle ME, Cisar NS, et al.** Use of continuous subcutaneous insulin infusion (insulin pump) therapy in the hospital setting: proposed guidelines and outcome measures [erratum in *Diabetes Educ.* 2006;32:130]. *Diabetes Educ.* 2005;31:849-857.
2. **Leonhardi BJ, Boyle ME, Beer KA, et al.** Use of continuous subcutaneous insulin infusion (insulin pump) therapy in the hospital setting: a follow-up analysis. *J Diabetes Sci Technol.* 2008;2:948-962.
3. The Joint Commission: Inpatient Diabetes Certification. Available at: <http://www.jointcommission.org/Certification/Programs/Inpatient+Diabetes/>. Accessed February 14, 2008.
4. **Knecht LA, Gauthier SM, Castro JC, et al.** Diabetes care in the hospital: is there clinical inertia? *J Hosp Med.* 2006;1:151-160.
5. **Cook CB, Castro JC, Schmidt RE, et al.** Diabetes care in hospitalized noncritically ill patients: more evidence for clinical inertia and negative therapeutic momentum. *J Hosp Med.* 2007;2:203-211.
6. **Queale WS, Seidler AJ, Brancati FL.** Glycemic control and sliding scale insulin use in medical inpatients with diabetes mellitus. *Arch Intern Med.* 1997;157:545-552.
7. **Clement S, Braithwaite SS, Magee MF, et al.** Management of diabetes and hyperglycemia in hospitals [errata in *Diabetes Care*;2004:856 and *Diabetes Care*;2004:1255]. *Diabetes Care.* 2004;27:553-591.
8. **ACE/ADA Task Force on Inpatient Diabetes.** American College of Endocrinology and American Diabetes Association consensus statement on inpatient diabetes and glycemic control. *Endocr Pract.* 2006;12:458-468.
9. **Cook CB, Moghissi E, Joshi R, Kongable GL, Abad VJ.** Inpatient point-of-care bedside glucose testing: preliminary data on use of connectivity informatics to measure hospital glycemic control. *Diabetes Technol Ther.* 2007;9:493-500.