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SYMPOSIUM

Comparison of Insulin Pump Therapy (Continuous Subcutaneous Insulin Infusion) to Alternative Methods for Perioperative Glycemic Management in Patients with Planned Postoperative Admissions

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Abstract

Background:

Patients with diabetes who use insulin pumps [continuous subcutaneous insulin infusion (CSII)] undergo surgeries that require postoperative hospital admission. There are no defined guidelines for CSII perioperative use.

Methods:

This retrospective single-institution study identified type 1 and type 2 diabetes subjects by electronically searching 2005–2010 anesthesia preoperative assessments for "pump." Surgical cases (n = 92) were grouped according to intraoperative insulin delivery method: (a) CSII *continuation* of basal rate with/without correctional insulin bolus(es) (n = 53); (b) *conversion* to intravenous insulin infusion (n = 20); and (c) CSII *suspension* with/without correctional insulin bolus(es) (n = 19). These groups were compared on mean intraoperative blood glucose (BG) and category of most extreme intraoperative BG.

Results:

Differences were found on baseline characteristics of diabetes duration (p = .010), anesthesia time (p = .011), proportions receiving general anesthesia (p = .013), and preoperative BG (p = .033). The conversion group had the longest diabetes duration and anesthesia time; it had a higher proportion of general anesthesia recipients and a higher mean preoperative BG than the continuation group. There was no significant difference in mean BG/surgical case between continuation (163.5 ± 58.5 mg/dl), conversion (152.3 ± 28.9 mg/dl), and suspension groups (188.3 ± 44.9 mg/dl; p = .128). The suspension group experienced a greater percentage of cases (84.2%) with one or more intraoperative BG > 179 mg/dl than continuation (45.3%) and conversion (40%) groups **Figure 1** groupings (p = .034).

continued →

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Abbreviations: (BG) blood glucose, (CSII) continuous subcutaneous insulin infusion, (PACU) postanesthesia care unit

Keywords: anesthesia, continuous subcutaneous insulin infusion, glucose, insulin, pump, surgery

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Abstract cont.

Conclusions:

In this limited sample, preliminary findings are consistent with similar intraoperative glycemic control between CSII continuation and CSII conversion to intravenous insulin infusions. Continuous subcutaneous insulin infusion suspension had a greater rate of hyperglycemia. Preoperative differences between insulin delivery groups complicate interpretations of findings.

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Introduction

Patients with type 1 and type 2 diabetes have been shown to benefit from improved glycemic control using insulin pumps [continuous subcutaneous insulin infusion (CSII)].[1–4] Patients proficient in diabetes self-management with CSII often request to retain CSII during hospitalization. High patient satisfaction (86%) with CSII self-management privileges has been reported.[5] The American Diabetes Association and the American College of Clinical Endocrinologists have encouraged development of institutional policies that guide safe practices when CSII is permitted in the hospital.[6,7] One key criterion in these institutional policies is substantiation of the patient's cognitive ability to self-manage CSII.[5–9]

Three primary options for perioperative glycemic management exist for patients using CSII: (a) continuing CSII (with supplemental intravenous or subcutaneous insulin, if required), (b) converting from CSII to intravenous insulin infusion, or (c) suspending CSII (with/without intermittent correctional insulin boluses). Subcutaneous insulin administration and CSII continuation have been advocated during outpatient surgery in the Society for Ambulatory Anesthesia Consensus Statement.[10] Conversion from CSII to intravenous insulin infusion is the preferred option for patients with major and/or emergent surgery, hemodynamic instability, or critical illness.[11]

The choice between continuation of CSII or conversion from CSII to another insulin delivery method may be unclear for a patient undergoing nonmajor surgery that requires postoperative admission. Anesthesia regional pain relief modalities, long-acting local anesthetic infiltration at the surgical site, and nonopioid analgesics often result in an alert, comfortable patient upon discharge from the postanesthesia care unit (PACU). If the patient is expected to eat shortly after the surgery, resuming postoperative CSII if discontinued preoperatively may present greater potential for glycemic derangement than CSII perioperative continuation. If postoperative vomiting, somnolence, and/or physical inability to manipulate the pump device are anticipated, conversion from CSII to another means of perioperative insulin delivery is indicated.

Even with multidisciplinary collaboration prior to surgery, the ability to achieve and maintain intraoperative glycemic control may be challenging. With CSII continuation, the anesthesia provider and awake patient should concur on basal setting adjustment and preoperative or postoperative bolus doses through the pump device. While under anesthesia, supplemental correctional insulin boluses may be necessary, and dosing should be based on the patient's insulin sensitivity. Smooth conversion from CSII to intravenous insulin infusions or suspension of CSII and use of intermittent correctional insulin boluses requires integration of the new insulin delivery modality with the waning effects of CSII, the current blood glucose (BG) value, and the BG trend. No studies have examined perioperative CSII management to guide these practices. The primary purpose of this study was to compare three glycemic management strategies and to evaluate intraoperative BG control.

Methodology

For this retrospective study, approval was obtained from the Beaumont Health Systems' Human Investigations Committee (HIC #2010-243) for data collection at the 1050-bed Royal Oak and 360-bed Troy, MI, campuses.

An electronic query of the word "pump" was performed on the anesthesia preoperative assessment database (January 2005–December 2010). From this "pump" list, records of surgical cases that had insulin documented as the pump content were accessed. Inclusion criteria were ≥age 18 years, type 1 or type 2 diabetes, nonparturient, elective surgical procedure, and postoperative hospital admission on the day of surgery to a regular surgical unit. Surgical cases were excluded if CSII therapy was discontinued prior to hospital arrival and an intermediate or long-acting basal insulin had been administered.

Demographics, diabetes type, diabetes duration, hemoglobin A1c (within 3 months, closest to surgical date), CSII basal rate, creatinine (within 1 year, closest to surgical date), and beta-blocker use data were recorded. Surgical specialty, anesthesia time, anesthesia type, and predominant postoperative pain control modality data were retrieved. Anesthesia time was defined as time between preoperative area patient assessment by the anesthesia provider and assumption of care by the PACU nurse. Anesthesia time typically exceeded operating room time by 10 to 20 min.

Blood glucose values were retrieved during the perioperative time and the first 18 h after discharge from the PACU. Anesthesia department guidelines advocated hourly intraoperative BG measurement for patients who received home insulin therapy and/or insulin perioperatively by any delivery method. Accu-Chek Inform glucometers (Roche, Basel, Switzerland) and LifeScan SureStep Flexx glucometers (Johnson & Johnson, Milpitas, CA) were routinely used for BG measurements at the Royal Oak and Troy campuses, respectively. Per hospital policy, quality control was checked daily on the point-of-care instruments. Laboratory technicians conducted semiannual correlative testing of the glucometers with laboratory equipment, with demonstration of acceptable variance of less than 15% in BG value. A time interval for BG measurement was calculated by dividing the anesthesia time (in minutes) for a surgery by the number of BG measurements taken during that surgery.

From 2005–2010, anesthesia department guidelines for intravenous insulin infusions and subcutaneous correctional insulin boluses were not uniform between the two Beaumont Hospital campuses. The CSII-specific portion of the anesthesia department perioperative guidelines were introduced at the Royal Oak campus in 2007 and at the Troy campus in 2010 (**Appendix**). Preoperative endocrinologist consultation was advocated in the CSII-specific perioperative guidelines. Evidence of endocrinologist consultation was noted.

Surgical cases were grouped according to documented insulin delivery method: (a) CSII *continuation* of basal rate with supplemental subcutaneous or intravenous correctional insulin bolus administration if determined appropriate by the anesthesia provider, (b) CSII *conversion* with disconnection in the preoperative area and subsequent initiation of intravenous insulin infusion, or (c) CSII *suspension* with disconnection prior to leaving the preoperative area and use of intermittent subcutaneous or intravenous correctional insulin boluses if determined appropriate by the anesthesia provider. Intravenous dextrose treatment was given as judged appropriate for all groups.

The three groups were compared on mean intraoperative BG/surgical case (defined as average of all BG measurements during surgery and the first PACU BG measurement). The groups were also analyzed by category of most extreme intraoperative BG/surgical case. The exclusive BG categories were defined as target range (all BG values 70–179 mg/dl), moderate hypoglycemia (one or more BG <70 mg/dl with none <40 mg/dl), severe hypoglycemia (one or more BG <40 mg/dl), moderate hyperglycemia (one or more BG >179 mg/dl with none >249 mg/dl), and severe hyperglycemia (one or more BG >249 mg/dl). Frequency of conversions between CSII and other insulin delivery methods in the first postoperative 18 h were recorded.

Analysis

Baseline characteristics, BG values, and BG measurement intervals were summarized for each CSII group with measures computed at the surgical case level. The sample size, mean, and standard deviation were calculated for continuous variables, while relative frequencies were provided for categorical variables. The data were first examined to determine if they met the assumptions of the statistical tests proposed for analysis. *P* values involving continuous characteristics were based on techniques for clustered data to account for the inherent association present among data from patients undergoing multiple surgeries. *P* values involving categorical characteristics were obtained using Pearson chi-square, with an exact computation as needed. All *p* values were two-sided, with a cutoff value of 0.05 for statistical significance. Statistical analysis used the SAS System for Windows Version 9.2.

Results

Inclusion criteria were met by 99 surgical cases. Five cases were excluded because intraoperative documentation of CSII status was missing. Two additional cases, in which CSII had been suspended and dextrose treatment had been initiated, were dropped from analyses. For these cases, the first intraoperative BG measurements were 65 and 70 mg/dl and anesthesia times were short (115 and 55 min, respectively). The remaining 92 cases (with 79 unique individuals) were analyzed. The surgical services that were represented include limb orthopedic (n = 26), spine (n = 24), vascular (n = 8), general (n = 8), gynecology (n = 12), and other (urology; plastics; gastrointestinal; and ear, nose, and throat; n = 14).

Fifty-two surgical cases at the Royal Oak campus and four cases at the Troy campus (61% of cohort) occurred after implementation of the perioperative CSII-specific guidelines. Forty-two cases (46%) had documented glycemic management recommendations from endocrinology prior to surgery. In adherence with endocrinology recommendations, 58% of cases maintained CSII intraoperatively, while 33% were converted from CSII to intravenous infusions. For unexplained reasons, the remaining cases had CSII discontinued without conversion to intravenous infusions.

Differences were found on baseline characteristics of diabetes duration (p = .010), anesthesia time (p = .011), proportions receiving general anesthesia (p = .013), and preoperative BG (p = .033; **Table 1**). The conversion group had the longest diabetes duration and anesthesia time. The conversion group had a higher proportion of general anesthesia recipients and a higher mean preoperative BG than the continuation group.

In the CSII continuation group, supplemental correctional insulin injections were administered in the operating room in 12 cases. A correctional insulin bolus was self-administered through the pump device in the preoperative area for one case. In the CSII suspension

Table 1.
Subject Characteristics[a]

	CSII continuation (n = 53)	CSII conversion to intravenous infusion (n = 20)	CSII suspension (n = 19)	P value
Baseline data				
Age (years)	51.5 ± 10.4	51.6 ± 11.9	55.3 ± 10.5	0.873
Gender (% male)	28.3	35.0	21.0	0.627
Body mass index	29.4 ± 6.4	29.0 ± 6.8	30.3 ± 9.3	0.719
Diabetes type (% type 1)	86.8	90.0	84.2	0.917
Diabetes duration (years)	25.2 ± 13.7 [1]	29.2 ± 16.6	26.9 ± 13.7	**0.010**
Creatinine mg/dl	1.49 ± 2.03 [12]	0.91 ± 0.32	0.99 ± 0.28 [1]	0.628
Beta-adrenergic blocking agent (% present)	28.3	40.0	26.3	0.568
Hemoglobin A1c (%)	7.63 ± 1.2 [21]	7.49 ± 1.0 [4]	8.29 ± 1.1 [6]	0.462
CSII basal rate (U/h)	1.2 ± .8 [3]	1.2 ± .9	1.4 ± .9 [5]	0.876
Preoperative BG[b] (mg/dl)	146.1 ± 62.8	196.8 ± 79.9	160.0 ± 86.3 [1]	**0.033**
Anesthesia data				
Anesthesia time[c] (hours)	2.68 ± 1.12 [1]	3.67 ± 1.67	2.64 ± 1.27	**0.011**
Anesthesia type (% general)	56.6	90.0	79.0	**0.013**
Pain control (% receiving perioperative opioid analgesics)	75.5	85.0	100.0	**0.051**

[a] Mean ± standard deviation, unless otherwise noted. Number of cases with missing data appear in brackets.
[b] First BG recorded in the preoperative area.
[c] Time from preoperative area patient assessment by anesthesia provided until patient care assumption by PACU nurse; typically 10–20 min longer than operating room time.

group, insulin injections were administered in the preoperative area or the operating room in eight cases. A correctional insulin bolus was self-administered preoperatively prior to pump device disconnection for one case. The mean intervals for BG measurement were 76.9, 57.5, and 83.7 min for the continuation, conversion, and suspension groups, respectively.

Primary Findings

There was no significant difference in mean BG/surgical case between continuation (163.5 ± 58.5 mg/dl; range 48–311 mg/dl), conversion (152.3 ± 28.9 mg/dl; range 103–213 mg/dl), and suspension groups (188.3 ± 44.9 mg/dl; range 118–302 mg/dl; p = .128). The suspension group experienced a greater percentage of cases (84.2%) with one or more intraoperative BG >179 mg/dl than continuation (45.3%) and conversion (40%) groups **Figure 1** groupings (p = .034; **Figure 1**). No subjects experienced severe intraoperative hypo-glycemia (BG < 40 mg/dl).

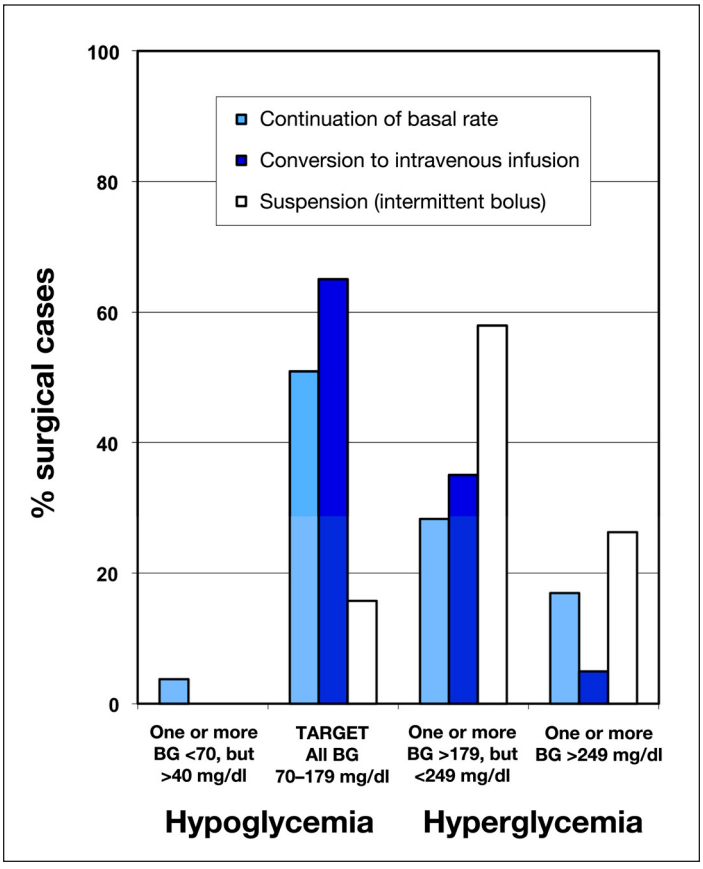

Figure 1. Comparison of insulin delivery methods to percentage of surgical cases with intraoperative hypoglycemia and hyperglycemia. Chi-square = 13.43, p = .034; continuation group, n = 53; conversion group, n = 20; suspension group, n = 19. All groupings were mutually exclusive. Intraoperative BG is defined as all BG measurements performed in the operating room and the first postoperative anesthesia care unit measurement.

Additional Findings

Six of 53 surgical cases in the continuation group (11%) had CSII discontinued in the PACU (n = 2) or within 6 h of surgical floor arrival (n = 4). Characteristics of the six cases that involved conversion from CSII in the postoperative period include general anesthesia recipient (n = 6), PACU Aldrete code "arouses on calling" (n = 4) versus "fully awake" (n = 2), and BG value >200 mg/dl (n = 5). Of the 39 cases that had CSII discontinued perioperatively, 18 cases (46%) had documented CSII re-initiation within 18 h post-PACU discharge. The mean time of re-initiation of CSII was 6.9 h after the recorded anesthesia stop time. The mean BG/surgical case for the first postoperative 18 h on the regular surgical unit was 168.1 ± 55.4 mg/dl for the CSII continuation group (n = 52), 163.0 ± 47.5 mg/dl for the CSII conversion group (n = 20), and 207.5 ± 63.0 mg/dl for the CSII suspension group (n = 17). In three cases, no BG values from the postoperative surgical unit had been documented in the hospital record.

Safety

No incidences of diabetic ketoacidosis or severe hypo-glycemia with loss of consciousness were recorded in the cohort during the perioperative or postoperative time. One subject in the continuation group (preoperative BG of 118 mg/dl; anesthesia time of 128 min; no intraoperative BG measurements) presented with a 48 mg/dl BG value on PACU arrival. In the continuation group, there was no evidence of intraoperative CSII technical problems (i.e., inadvertent disconnection, occlusions of infusion set, or pump failure to deliver).

Discussion

Blood glucose values between 70 and 180 mg/dl have been advocated as reasonable targets for most peri-operative patients with well-controlled diabetes.[11] In this study, intraoperative BG values and incidences of hypoglycemia and hyperglycemia were found to be similar between the surgical cases in which CSII (insulin pumps) was continued and those cases in which CSII was replaced by intravenous insulin infusions. These preliminary findings suggest that CSII continuation (accompanied by correctional insulin boluses based on anesthesia provider clinical judgment) is generally safe and may be considered in noncritical patients with planned postoperative hospital admissions. The study's sample size is, however, inadequate to conclude that no differences exist in mean intraoperative BG values between the glycemic management options. Suspension of

CSII with subsequent intermittent insulin boluses was less successful in hyperglycemia avoidance than CSII continuation or conversion to intravenous insulin infusions.

The existence of anesthesia department CSII guidelines and endocrinology preoperative consultations during the latter years of this study must be considered in interpretation of these results (**Appendix**). In a survey of 249 United States hospitals, 44% responded that full or partial perioperative glycemic control protocols were in place.[12] Within institutions that have perioperative protocols, the prevalence of CSII-specific guidelines is unknown. Broad CSII considerations for the perioperative time have been mentioned in the literature,[13–15] and several CSII-specific instructions were included in one institution's perioperative physician order set.[16] Another institution found inconsistent documentation of perioperative CSII use and BG monitoring[17] and subsequently published standardized perioperative CSII guidelines with a checklist.[18]

Continuous subcutaneous insulin infusion had been continued perioperatively for the majority of the surgical cases in this study. Anesthesia-related differences detected between the three CSII groups (**Table 1**) were likely due to discernment by care providers in choice of insulin delivery method. As discussed earlier, CSII continuation is conditionally appropriate in the hospital setting. Planned general anesthesia, projected longer surgical times, and probable postoperative opioid analgesia requirements are presumed to have influenced the decision to discontinue CSII for the intraoperative period. Anticipated postoperative drowsiness was likely recognized as a contraindication for CSII self-management in patients with the aforementioned factors. Several unaddressed variables may have also influenced choice of intraoperative insulin delivery method (i.e., patient preference, anesthesia or diabetes care provider general preference, patient expertise in CSII management, and CSII proximity to surgical site).

Preoperative hyperglycemia appears to have effected more frequent conversion to intravenous insulin infusions by anesthesia providers. Intravenous medication route provides more immediate and reliable insulin administration than the subcutaneous route, and thus the intravenous route has been suggested as the preferable delivery route during surgery.[19] Only the conversion group showed a decrease between mean preoperative BG (197 mg/dl) and mean intraoperative BG (152 mg/dl). This finding suggests that, in circumstances where hyperglycemia treatment is indicated prior to surgery, conversion to intravenous insulin infusion may be the preferred choice.

A higher percentage of cases experienced BG >179 mg/dl in the suspension group than the continuation and conversion groups. The lower incidences of hyperglycemia in the conversion group (despite the increased mean preoperative BG) may be attributed to the proactive approach advocated by the perioperative CSII-specific guidelines and perhaps the increased BG monitoring frequency. When the CSII-specific guidelines had been followed, the intravenous insulin infusion would have been commenced within 30–60 min of discontinuing CSII (provided preoperative BG was 100–179 mg/dl). The intravenous insulin infusion adjustments (based on the difference between current and previous BG) aimed at a BG target of 140–179 mg/dl. Alternatively, for the continuation and suspension groups, anesthesia department subcutaneous correctional insulin scales reactively recommended correction when BG was >179 mg/dl. The conversion group's lowest mean interval between BG measurements was likely due to an anesthesia provider culture of strict adherence to hourly monitoring with use of the intravenous infusion delivery route.

In patients on intensive insulin regimens via CSII delivery, the basal insulin component is continually delivered through the pump device. Discontinuation of CSII without prompt replacement of this specified basal insulin component is another possible explanation for the highest percentage of cases experiencing one or more hyperglycemic values in the suspension group. Initiation of long-acting subcutaneous basal insulin perioperatively should perhaps be considered if CSII must be discontinued and insulin replacement with an intravenous infusion is not feasible. When converting from CSII to multiple daily injections in the hospital, dual daily dosing of long-acting peakless basal insulin may allow more flexibility in basal insulin dose adjustments and ease in eventually converting back to CSII.[20]

Frequent BG monitoring and assessment of CSII self-management capability for all patients appears essential in the PACU and in the first postoperative day. Six subjects who used CSII during surgery had it discontinued in the early postoperative period, whereas 18 subjects who had not used CSII intraoperatively resumed CSII self-management within the first 18 postoperative hours. Varying timeframes of these CSII two-way conversions in the postoperative period precluded comparative statistical analysis of postoperative BG values. The mean BG values/surgical case during the first postoperative

18 h (168 mg/dl for the continuation group and 163 mg/dl for the conversion group) generally coincided with values in hospitalized CSII patients from other reports.[5,17]

Limitations of the study include small sample size, retrospective design, and numerous confounding factors. The analysis was not time weighted for the mean BG values. Anesthesia department perioperative guidelines for intravenous insulin infusions and subcutaneous correctional insulin boluses varied between the two Beaumont Health System campuses. CSII-specific perioperative guidelines existed only during the latter part of the study, and adherence to the CSII guidelines was inconsistent.

Conclusion

Intraoperative glycemic control in patients who continued their insulin pumps (CSII) during surgery appeared similar to control in patients who were converted from their insulin pumps to intravenous insulin infusions. The highest percentage of cases experiencing one or more episodes of intraoperative hyperglycemia occurred with CSII suspension. This study has produced preliminary data that may assist in proper design of a multicenter prospective clinical trial.

Disclosures:

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Appendix: Information for Patients Who Use Insulin Pumps

- The day before you come to the hospital, change batteries in the pump. Before 6:00 PM, change the infusion set and site. The pump site should be opposite or away from the location of your surgery.

- Please bring your emergency kit to the hospital consisting of 2–3 infusion sets, 2–3 reservoirs, spare batteries, bottle of insulin, meter with extra test strips, glucose tablets, patient logs, and a 24 h record of all your current basal settings.

- Check your blood sugar when you wake up on the day of surgery:

  - If less than 80 mg/dl, take three glucose tablets or drink four ounces of apple juice *or* four ounces regular 7UP only. (No orange juice!)

  - If elevated (especially if greater than 250 mg/dl), because you are not able to eat, we strongly prefer (for your own safety) that you are at the hospital and confer with an anesthesiologist before bolusing insulin through your pump.

  - In either of these situations, please be driven to the hospital shortly afterward (even if it's earlier than the time you were asked to arrive). Let the registration clerk know that you were instructed to have your blood sugar checked by a nurse on hospital arrival.

What to Expect for an Outpatient Procedure

- We usually leave the pump running at your basal rate during surgery.

- We will ask you about your basal rate(s) and how much 1 U of insulin will lower your blood sugar.

- If you will be wearing the pump during surgery, you will be asked to show our team how to disconnect and suspend your pump it if the need arises.

- We will request that you sign an equipment waiver form (required for all outside medical equipment that is brought into the hospital).

What to Expect for an Overnight Hospital Stay:

- The anesthesia department has requested that surgeons communicate with endocrinologists about a diabetes management plan for patients who will be admitted after surgery to regular surgical units. *Please contact your endocrinologist to discuss this plan.* Your endocrinologist should send a written copy of the plan to our anesthesia prescreening department. (We suggest that you request a written copy to bring in on the day of surgery.) The anesthesiologist will review the plan with you on the day of surgery.

- If you are having surgery that will require admission to the intensive care unit, you do not need a plan from your endocrinologist. We will ask you to stop the pump right before surgery, and you will receive intravenous insulin during and after your surgery.

- Options other than using your insulin pump while at the hospital are an intravenous infusion of insulin or subcutaneous insulin injections.

- If you stop your pump, it should be given to a family member for safekeeping.

Appendix: Anesthesia Perioperative Insulin Pump Planning Sheet

(Complete only for patients who will be admitted postoperatively to a regular surgical unit.)

Patient Name: DOB:

Surgeon:_____ Phone:_____ Fax:_____

Date of surgery:_____ Procedure: _____ Length:_____

Postoperative analgesia plan: (circle all that apply)

Narcotic analgesics: IV IM PO Regional Block Epidural Local

Do you think your patient will be alert and able to manage his/her insulin pump on arrival to the floor?

□ Yes □ Unsure □ No

Surgeon Signature: _____ Date:_____

Endocrinologist:_____ Phone:_____ Fax:_____

Perioperative/Postoperative Glucose Control:

□ This patient is expected to manage his/her insulin pump. If the patient is not able to manage the pump, please consult the endocrinologist prior to leaving the PACU.

□ This patient is not expected to manage his/her pump upon discharge from the PACU. Discontinue insulin pump and follow alternative plan for perioperative/postoperative glucose management (please select one of the following options):

- □ Convert to IV insulin infusion per anesthesia protocol for perioperative management.
- □ Continue IV insulin infusion on surgical unit per WBH guidelines.
- □ Other:_____

Postoperative Glucose Medical Management:

□ I will be responsible for postoperative care. Please consult me when the patient arrives on the floor.

□ I will be transferring postoperative care to: _____ Phone:_____

□ Please have surgeon consult a WBH endocrinologist for postoperative management.

Endocrinologist Signature: _____ Date_____

Please return to Anesthesia Advanced Testing Department at least two business days prior to surgery.

Appendix: Perioperative Insulin Pump Information Sheet

Reminder: To be admitted to a regular floor or short-stay, assure that patient has a designated WBH diabetes physician with expertise in insulin pump management. The Inpatient Insulin Pump Postoperative Planning Sheet should be on the chart. If no WBH diabetes physician expert was established or consulted ahead of the surgery, see list in unit folder for list of endocrinologists. Endocrinologists request notification from preop area of the patient arrival and anticipated length of surgery.

Preop RN, CRNA, or anesthesiologist, complete for all patients:
(Please interview the patient and document the answers below.)

1. Current basal rate (average rates are 0.8 to 1.2 U/h) _____U/h.

   Describe any preprogrammed rate changes that will occur during the case:

   _____

2. Type of insulin in insulin pump:_____

3. Insulin sensitivity. Answer one of the following:

   (a) What is your total daily dose of insulin (basal plus bolus)? _____U

   or

   (b) How much will 1 U of insulin lower your blood sugar? _____mg/dl

4. Location of insulin pump:_____

5. Site is dry and free from redness: yes no

   If no, explain _____

Signature:_____Date:_____Time

CRNA or anesthesiologist: only complete if patient will wear the insulin pump during the surgery. Only the patient makes rate changes or gives insulin boluses through the pump.

Pump is set on "audible alarm" yes no

Patient and anesthesiologist have signed equipment waiver yes no

Demonstrate to CRNA or anesthesiologist how to first "disconnect" the pump and then "suspend" the pump. Please record steps to suspend.

Step 1:

Step 2:

Step 3:

Signature:_____ Date:_____ Time:_____

Continuation of CSII (pump)

Glucose monitoring is required every 1 h during perioperative phases.

Documentation:

1. Preop Insulin Pump Information Sheet
2. Equipment Waiver Form

Clinical Parameters:

BG < 100 mg/dl

- Treat according to periop hypoglycemia guidelines
- Consider temporary basal rate for duration of procedure +2 h for recovery
- Recommend decreasing basal rate 20%
- Intra-op hypoglycemia: treat with dextrose per guidelines

BG 100–170 mg/dl

- Maintain pump at usual basal rate

BG ≥ 179 mg/dl

- Instruct patient to correct BG through insulin pump
- Intra-op hyperglycemia: Treat with Novolog (aspart) SQ based on insulin sensitivity (amount 1 U of insulin will lower BG); may be referred to as correction factor

When to disconnect and convert to IV insulin:

- Large blood loss, shock, or change in condition requiring ICU
- Continuous alarm sounds indicating pump is not delivering
- Catheter becomes dislodged
- Admits: patient may be ready for PACU discharge but is either cognitively or physically unable to self-manage insulin pump (test own glucose, make decisions on insulin dosing)

Discontinuation of CSII (Pump)

Requires conversion to IV insulin infusion

Glucose monitoring is required every 1 h during perioperative phases.

Establish separate IV access for IV insulin infusion

Clinical Parameters:

BG < 100 mg/dl

- Treat according to hypoglycemia guidelines
- *Start* infusion once BG 100 mg/dl or greater

BG 100–179 mg/dl

- *Start infusion:* initial dose equals basal dose
    - Start 30–60 min after pump stopped
- *Do not bolus* IV insulin
- *Titrate* in *30 min* from IV start time, then every 1 h

BG ≥ 179 mg/dl

- *Start infusion* based on current glucose
- *Do not bolus* IV insulin
- *Titrate* in *30 min* from IV start time, then every 1 h

Caution

If patient treated high blood sugar through insulin pump in previous 3 h, *monitor glucose and begin IV infusion once BG trending up.*

If restarting insulin pump in postop, *start insulin pump* 30–60 min *before* discontinuation of IV insulin.