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SYMPOSIUM

Improvement in Glycemic Control and Outcome Corresponding to Intensive Insulin Therapy Protocol Development

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Abstract

Background:

Intensive insulin therapy (IIT) has been shown to reduce mortality and morbidity in longer stay, critically ill patients. However, this has been demonstrated in a single site, whereas two multicentric studies have been terminated prematurely mainly due to hypoglycemia. Other difficulties with IIT include efficacy of glycemic control. This report describes how IIT can be improved by protocol simplification and removal of glucose supplementation.

Methods:

A clinical information system established at each bedspace guided staff through the IIT algorithms. Time spent within predefined glycemic ranges was calculated assuming a linear trend between successive measurements. Three groups were investigated retrospectively: IIT1 protocol,[1] an updated IIT2 version, and intuitive nurse dosing of conventional insulin therapy (CIT).

Results:

Fifty consecutive, critically ill patients were included in each study group. Patient characteristics were similar in each group. The frequency of CIT and IIT2 blood glucose measurements were 11.6 and 11.5 measurements per day, respectively, while the IIT1 measurements were more frequent (14.5 measurements per day). The mean proportion of time spent in the target glycemic range (4.4–6.1 mmol/liter) was highest in the IIT2 group (34.9%), as compared to the IIT1 (22.9%) and CIT groups (20.3%) (p <.001). Survival at 28 days was 74.5% for IIT2 (highest), 68% for IIT1, and 48% for CIT (p = .02). There were a similar number of those experiencing a severe hypoglycemic event in each group.

continued →

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Abbreviations: (APACHE) Acute Physiology and Chronic Health Evaluation, (BG) blood glucose, (CIT) conventional insulin therapy, (ICU) intensive care unit, (IIT) intensive insulin therapy, (IQR) interquartile range, (TGC) tight glycemic control

Keywords: blood glucose, critically ill, insulin, tight glycemic control

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Abstract cont.

Conclusions:

IIT protocol optimization was associated with increased glycemic control and improved 28-day survival. The better optimized IIT2 protocol provided tighter control than either the IIT1 or CIT protocol, without increased sampling or incidence of hypoglycemia. The clinical effectiveness of the IIT algorithm appeared to be improved by simplifying the protocol to meet the needs of the critical care unit.

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Introduction

Intensive insulin therapy (IIT) has been shown to reduce mortality and morbidity in longer stay, surgical and medical intensive care patients, compared to patients in a "conventional insulin therapy" (CIT) group.[2,3] The two studies that have shown these benefits originated from a single centre where the IIT target blood glucose (BG) was 4.4–6.1 mmol/liter, while the CIT target was 10–11.1 mmol/liter. However, this IIT glycemic target has not been universally adopted as data emerged that a more liberal control may also be beneficial.[4] A variety of glycemic target ranges have been used both in clinical practice[5] and in other published studies.[6] The Surviving Sepsis guidelines[7] advocate keeping BG below 8.3 mmol/liter rather than within the tighter glycemic range of 4.4–6.1 mmol/liter advocated by Van den Berghe.[2,3] This may have been because the major published outcome studies originated from a single centre, and few septic patients have been included in the IIT studies. This more cautious approach is supported by the results of two studies that reported a higher incidence of severe hypoglycemic events (BG <2.3 mmol/liter) with IIT, with no improvement in outcome.[8,9]

IIT protocols are used in order to attempt to achieve tight glycemic control (TGC). There is no consensus on the most effective protocol.[6] We previously described glycemic control achieved by a novel computerized decision-supported IIT protocol (IIT1), aiming for a BG target of 4.4–6.1 mmol/liter.[1] However, glycemic control was not optimal, with only 23% of time spent in the target glycemic range. We set out to determine whether a revised protocol (IIT2) using the same technology would improve glycemic control, be less labour intensive, and influence patient outcomes. These outcomes were compared to those of a historical control group who were treated with conventional insulin therapy (CIT).

Subjects and Methods

At our general, adult, 22-bed (upgraded recently to 27-bed) intensive care unit (ICU), an observational retrospective study was conducted in 50 consecutive ICU patients treated with IIT1 (January to June 2005). These data have been described previously but are included here for comparative purposes. The 50 consecutive patients treated with CIT were admitted before January 10, 2005 mechanically ventilated >48 hours, and treated with standard insulin. The CIT patients were treated before IIT was introduced but would have satisfied the entry criteria for the IIT1 protocol. CIT patients were treated with insulin in a nonprotocolized, intuitive manner by the nurse, with a target BG level of 4–10 mmol/liter. The frequency of BG monitoring in the CIT patients was not protocolized and was at the discretion of the bedside nurse.

The entry criteria for the IIT1 protocol was mechanically ventilated ICU patients who on admission were expected to be ventilated for at least 24 hours. The IIT1 protocol used was based on a published protocol[10] in which the frequency of BG measurement was related to control of glycemia, varying from every 15 minutes to 4 hours depending on the degree of BG control. The main exclusion criteria for all groups were patients with diabetic emergencies.

The third group comprised 51 consecutive patients from September to December 2006, managed with the revised IIT2 protocol (**Appendix 1**). The IIT2 protocol differed from IIT1 with respect to less frequent BG sampling and removal of glucose supplementation until full nasogastric feeding was established. This was because this supplementation had been highlighted previously as

a factor that predisposed patients to hyperglycemia in the first 72 hours of IIT.[1] Furthermore in IIT2, mechanical ventilation was no longer a requisite. Patients expected to stay three days or more in ICU were suitable for IIT2.

The GE Medical QS clinical information management system was available at every bedspace. Arterial blood glucose measurements were assayed with a glucometer and blood gas machine for the IIT patients, and just the latter method for the CIT patients. Glucometer readings were obtained from Glucometer Elite™ (Bayer Diagnostics, Tarrytown, NY) and the ICU blood gas analyzer used was ABL 625 Radiometer (Crawley, UK). All BG results were analyzed with a Microsoft Excel spreadsheet, assuming a linear trend between successive measurements to estimate the time that each patient spent within predetermined glycemic ranges. This summary was collated for each patient and the results analyzed using SPSS 15.0 for Windows (SPSS Inc., Chicago, IL). This method was used in our previous study.[1] Two-tailed *t*-tests were used to compare means for parametric data in two groups, and Mann-Whitney tests were used to compare nonparametric data in two groups. Chi-square test was used to analyze percentage data. One-way analysis of variance was used to analyze parametric means of three groups of data. The Kruskal-Wallis test was used to analyze nonparametric data in three groups.

Results

Patient characteristics are shown in **Table 1**. The treatment groups were well matched for age, gender, admission disease severity [Acute Physiology and Chronic Health Evaluation (APACHE II) score], and history of diabetes. In each group, the majority of subjects were medical patients, and the proportion did not differ significantly between the groups, though there were numerically more surgical patients in IIT2 versus CIT.

The details of glucose control in the three protocol groups are shown in **Table 2**. The cumulative comparative glucose control data is shown in a box and whisker plot in **Figure 1** and in cumulative form in **Figure 2**.

The patient outcomes and details of glucose control are shown in **Table 3**. The percentage of time in the target glycemic range (4.4–6.1 mmol/liter) was highest in the IIT2 group (**Table 2**). There was no difference in the percentage of time spent in the hyperglycemic range (>11.1 mmol/liter). Similarly, there was no significant difference in the number of patients who experienced severe hypoglycemic events (BG <2.2 mmol/liter) (**Table 3**), which was approximately 10% in each group. The mean number of daily BG readings used to guide insulin therapy was lower in IIT2 (11.5) than in IIT1 (14.5), and

Table 1.
Baseline Characteristics

	IIT2 (*n* = 51)	IIT1 (*n* = 50)	CIT (*n* = 50)	*p* value comparing three groups (*p* value comparing IIT1 and IIT2)
Age (year) Mean (SD)	61.8 (14.6)	61.8 (15.5)	65.7 (15.1)	.33[b] (>0.99[c])
Weight (kg) Mean (SD)	76.2 (15.5)	76.5 (17.2)	72.3 (18.0)	.51[b] (.93[c])
Gender (male) Number (%)	35 (68.6%)	34 (68.0%)	27 (54.0%)	.23[a] (.88[a])
APACHE II score Mean (SD)	25.2 (7.9)	23.2 (7.7)	25.4 (8.5)	.31[b] (.20[c])
Surgical patient Number (%)	20 (39.2%)	18 (36.0%)	12 (24.0%)	.23[a] (.90[a])
Medical patient Number (%)	31 (60.8%)	32 (64.0%)	38 (76.0%)	
Mechanically ventilated Number (%)	47 (92.2%)	50 (100.0%)	50 (100.0%)	.02[a] (.13[a])
History of diabetes Number (%)	8 (15.7%)	6 (12.0%)	4 (8.0%)	.49[a] (.80[a])

[a] chi-square test
[b] one-way analysis of variance
[c] two-tailed *t*-test

Table 2.
Comparative Percentage Time in Glycemic Bands in the Three Protocol Groups

	IIT2 (n = 51)	IIT1 (n = 50)	CIT (n = 50)	p value comparing three groups (p value comparing IIT1 and IIT2)
Time % within BG range 0–2.2 mmol/liter mean (95% CI)	0.0 (0.0–0.0)	0.0 (0.0–0.1)	0.0 (0.0–0.1)	.52[a] (.43[b])
Time % within BG range 2.3–4.3 mmol/liter mean (95% CI)	3.4 (2.0–4.9)	3.0 (1.8–4.3)	3.4 (1.9–5.0)	.91[a] (.68[b])
Time % within BG range 4.4–6.1 mmol/liter mean (95% CI)	34.9 (30.1–39.8)	22.9 (19.4–26.4)	20.3 (16.5–24.0)	<.001[a] (<.001[b])
Time % within BG range 6.2–8 mmol/liter mean (95% CI)	41.8 (37.3–46.3)	46.0 (40.8–51.2)	45.7 (40.8–50.5)	.40[a] (.24[b])
Time % within BG range 8.1–10 mmol/liter mean (95% CI)	13.6 (10.1–15.1)	17.0 (13.6–20.3)	21.7 (18.2–25.3)	<.001[a] (.04[b])
Time % within BG range 10.1–11.1 mmol/liter mean (95% CI)	3.8 (1.7–4.5)	4.6 (2.3–6.8)	3.9 (2.4–5.5)	.35[a] (.18[b])
Time % within BG range >11.1 mmol/liter mean (95% CI)	5.9 (1.4–7.8)	6.5 (2.9–10.0)	5.0 (2.7–7.2)	.59[a] (.37[b])

[a] one-way analysis of variance
[b] two-tailed t-test

was similar to those conducted with CIT (11.6). Patient survival at 28 days after ICU admission was increased with IIT2. There was a trend toward improved survival with IIT1 versus CIT (p = .07).[11]

Improvements in the proportion of time in the target glycemic range (4.4–6.1 mmol/liter) were found in IIT2 compared with IIT1 and CIT (34.9, 22.9, and 20.3%, respectively). This difference was consistent among survivors and nonsurvivors after 28 days, and short (<3 days) and longer courses (≥3 days) of insulin therapy (**Table 4**).

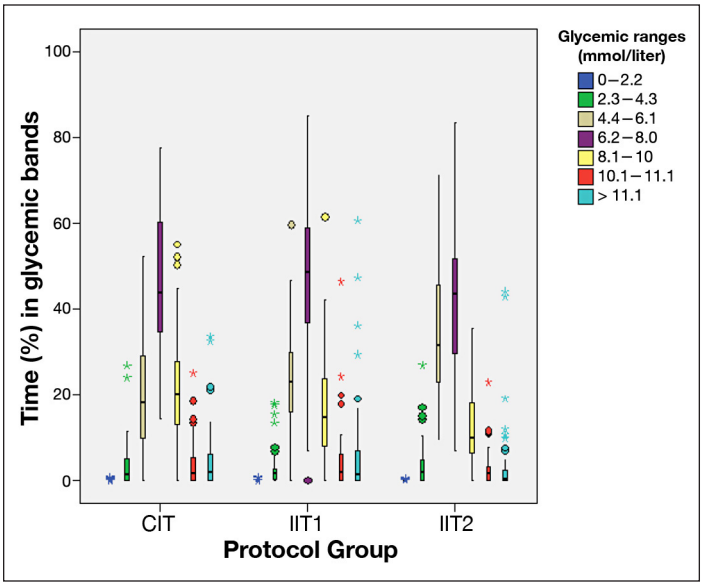

Figure 1. Box and whisker plot of BG measurements represented in terms of percentage time (%) in predefined glycemic ranges. The target for IIT was 4.4–6.1 mmol/liter.

The length of ICU stay was longer for IIT than for CIT (**Table 3**). However, in 28-day survivors, there was no significant difference in the length of ICU stay. There was no difference in the length of IIT course in the two IIT groups. In the three groups, the proportion of patients hemofiltered did not differ, neither did the median number of days mechanically ventilated.

Discussion

Despite the large, single centre studies showing the benefits of IIT,[2,3] there are large variations in practice,[12] and this has proved to be a contentious area of ICU practice.[13] The main concerns are related to the risk of hypoglycemia, the additional workload necessary, and the complex protocols. We addressed these issues by comparing an updated IIT protocol with our original protocol and previous conventional practice.

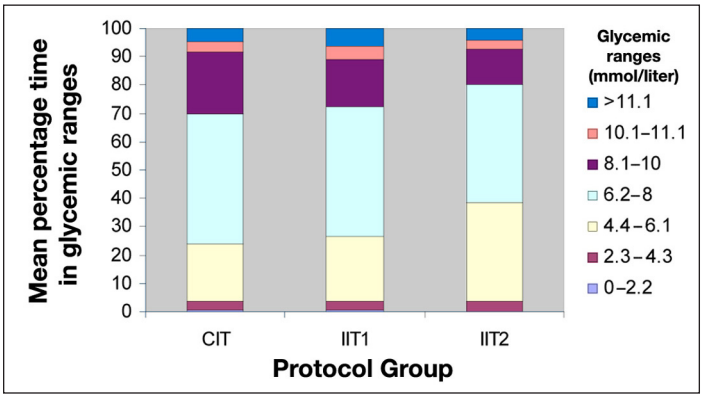

Figure 2. Stacked bar chart of BG measurements represented in terms of percentage time (%) in predefined glycemic ranges. The target for IIT was 4.4–6.1 mmol/liter.

Our key finding was that optimization of our IIT protocol (IIT2) was associated with tighter glycemic control and an improved survival compared to the CIT group. These improvements, noted with our updated protocol, were seen despite less frequent monitoring. An explanation for the reduced BG monitoring may result from the improved glucose control in IIT2, since the protocol specifies less frequent monitoring when control is satisfactory (**Appendix 1**).

Our second finding was that the development of IIT is a continuous, individualized process. While our initial protocol (IIT1) had several flaws (e.g., too frequent BG monitoring and excessive glucose supplementation), many

Table 3.
Study Outcome

	IIT2 (n = 51)	IIT1 (n = 50)	CIT (n = 50)	p value comparing three groups (p value comparing IIT1 and IIT2)
Patients experiencing severe hypoglycemia Number	5	5	6	.93[a] (.76[a])
Glucose readings per day Mean number (SD)	11.5 (3.3)	14.5 (5.7)	11.6 (3.3)	<.001[b] (<.001[d])
Survival at 28 days Number (%)	38 (74.5)	34 (68)	24 (48)	.02[a] (.62[a])
28-day survival surgical patient Number (%)	18 (90)	14 (77.8)	7 (58.3)	.11[a] (.57[a])
28-day survival medical patient Number (%)	20 (64.5)	20 (62.5)	17 (44.7)	<.001[a] (.90[a])
Length of ICU stay (days) Median (IQR)	8.0 (3.0-19.0)	7.0 (3.0-21.3)	6.0 (2.8-11.0)	.05[c] (.79[e])
Length of ICU stay of survivors (days) Median (IQR)	10.5 (3.8-21.5)	7.5 (3-24.8)	6.5 (2.3-12.0)	.20[c] (.98[d])
Length of IIT course (days) Median (IQR)	3.5 (1.9-11.4)	4.6 (1.6-11.9)	not applicable	(.88[d])
Patients hemofiltered Number (%)	21 (41.2)	13 (26)	15 (30)	.47[a](.16[a])
Days mechanically ventilated Median (IQR)	4.0 (2.0-13.0)	5.5 (2.0-15.3)	5.0 (3.0-10.3)	.44[b] (.26[e])

[a] chi-square test
[b] one-way analysis of variance
[c] Kruskal-Wallis test
[d] two-tailed t-test
[e] Mann-Whitney test

Table 4.
Comparative Target Glucose Control in Relation to Length of Insulin Course and Survival

	Time % within BG range 4.4–6.1 mmol/liter Mean (SD)			
	IIT2 (n = 51)	IIT1 (n = 50)	CIT (n = 50)	p value comparing three groups (p value comparing IIT1 and IIT2)
Length of insulin course <3 days	39.1 (20.2) n = 22	19.3 (16.1) n = 21	21.6 (17.2) n = 12	<.001[a] (<.001[b])
Length of insulin course ≥3 days	31.8 (13.9) n = 29	25.5 (8.1) n = 29	19.8 (11.8) n = 38	<.001[a] (.04[b])
Survivor at 28 days	35.1 (18.9) n = 38	24.2 (12.3) n = 34	20.1 (14.4) n = 24	<.001[a] (<.001[b])
Nonsurvivor at 28 days	34.6 (11.2) n = 13	20.2 (12.4) n = 16	20.4 (12.1) n = 26	<.001[a] (<.001[b])

[a] one-way analysis of variance
[b] two-tailed t-test

of these were resolved in IIT2, and this corresponded with improvements in target glycemic control and mortality, and a reduction in BG monitoring, with no change in the incidence of severe hypoglycemic events. These reported improvements may reflect that it can take time for an organization to adjust to the demands of embracing an IIT protocol. It is clearly time consuming and certainly in this case our protocols were difficult for the nurses to follow. This was overcome in our case by using computerized decision-support to simplify the action points in relation to each BG measurement. There does not currently appear to be a "one size fits all" approach to TGC, with variation in target glycemic range and protocols.[5,12,14,15]

Thirdly, we found that the proportion of patients who experienced a severe hypoglycemic episode did not differ between the CIT and two IIT groups. This is in stark contrast to the surgical Leuven study,[2] in which 5.1% of IIT patients experienced one or more hypoglycemic episodes. In the medical Leuven study,[3] the incidence more than tripled to 18.7% in the IIT group. In the VISEP study,[9] an incidence of 17.0% was sufficient for the study to be terminated prematurely. Similarly, in the currently unpublished Glucontrol study,[8] the incidence in the IIT group was 8.6%. Equally of interest is the low incidence of severe hypoglycemia noted in these studies in the "CIT" groups (0.8,[2] 3.1,[3] 2.1,[9] and 2.4%,[8] respectively), which are much lower than the 12% seen in our study. A possible explanation for this discrepancy is that our CIT was "genuine" conventional insulin therapy with a target of 4–10 mmol/liter, whereas the other studies used the target of 10–11 or 11.1 mmol/liter (the Glucontrol study used a CIT target of 7.8–10.0 mmol/liter[8]), which does not correspond with conventional practice. This may lead one to question whether the incidence of severe hypoglycemia is really so different in IIT and genuine CIT.

Other models of TGC include intuitive insulin dosing managed by experienced nurses. New, computerized, closed-loop systems that monitor BG continuously and control insulin dose adaptively are being developed.[16,17] The SPRINT model based approach that manages TGC on the basis of controlling nutritional intake in addition to insulin,[18,19] has provided extremely promising results. The GRIP computerized decision-support in a short stay, cardiac ICU, aiming for a target BG of 4–7.5 mmol/liter,[20] has been reported to provide good glycemic control. The Glucommander™ insulin dosing software is reported to provide good glycemic control from a mixed patient group, however, evidence from critically ill patients has not been separately reported.[21]

The variations in practice may converge when the major controversies are resolved in this field, but in the meantime, the approach described here of individual improvement based on experience and analysis may be beneficial.

The reasons for the clear improvement seen with IIT2 over IIT1 and CIT may be multifactorial. Our interpretation is that IIT1 did not provide superior glycemic control to CIT because of the supplemental glucose load in IIT1, which will be explored later. The ability of CIT to control BG, with intuitive insulin dose adjustment, is dependent upon nurse experience. While this approach lacks standardization, humans have the ability to learn from previous response, in marked contrast to the static protocols used in IIT1 and IIT2. The trend toward improved survival with IIT1 versus CIT may reflect the benefits of the concept of IIT and TGC. The success of IIT2 may reflect the beneficial impact of refining the protocol, based on the feedback particularly from nurses stating that the frequency of BG monitoring in IIT1 was too complex and was not feasible to follow. Nurse "buy-in" for IIT2 appeared to increase because the protocol was easier to follow.

We attribute the improvement in glycemic control with IIT2 over IIT1 to a reduced glucose load with the updated protocol, before full enteral feeding was fully established. This would suggest that the initial glucose levels were lower in the first few days of IIT, when patients are typically most insulin resistant. Although we were not able to compare insulin doses, our perception is that lower doses were used with IIT2. The insulin dose has been identified previously as an independent risk factor for mortality in critically ill patients.[4,22] Furthermore, it has been contended that IIT maintained normal BG levels in critical illness by only transiently elevating insulin concentration, suggesting an improvement in insulin sensitivity after a few days of IIT.[23] Our results appear to be consistent with these findings, and the approach of glucose supplementation whilst building up additional feeding should be regarded as questionable.

To gain further insight into these results, one may speculate on the key differences between the patients groups and between the treatment protocols. We think that the improved performance of IIT2 was due to the removal of the glucose load that was used in IIT1. This was most evident in the patients with short IIT courses (**Table 4**), in whom glucose control was substantially improved with IIT2. Previously, we described how with IIT1 there was significant hyperglycemia noted in

the first 36 hours of IIT therapy, which we attributed to the coadministration of enteral feeding and glucose loading.[1] Although not statistically different, there were a numerically higher proportion of medical patients in the CIT group than in the IIT1 and IIT2 groups (**Table 1**). All the patients in IIT1 and CIT were mechanically ventilated as this was part of the criteria for assignment to these groups. However, in IIT2, mechanical ventilation was not a requirement for IIT. Despite this, 92% of patients in IIT2 were mechanically ventilated.

A limitation of this study is that it was a retrospective cohort study. The use of historical controls does not allow the presumption of a causal effect of the associations described. Finally, it was not possible to record the insulin doses.

Our study demonstrates that our initial IIT protocol did not provide superior TGC to our CIT. However, TGC was improved by removing glucose supplementation and simplifying the monitoring of the IIT protocol. This improvement coincided with reduced monitoring and improved mortality, with no change in the incidence of severe hypoglycemia. Computerized decision-support played a key role in the ease of application of the IIT protocols.

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Appendix 1.
UCLH ICU Intensive Insulin Therapy Protocol: A Stepwise Approach

Dr. Paul Glynne, Rob Shulman, Liz Morton (August 2006)

STEP 1.

Is Your Patient Eligible For Intensive Insulin Therapy Protocol?
Protocol Entry Criteria And Checklist:

All eligible patients **must** be:

- Within **24 hours** of this admission to intensive care
- Likely to be in ICU for at least three days (they do not need to be mechanically ventilated)

All eligible patients **must** have:

- An indwelling **arterial cannula** for blood glucose measurements
- A **dedicated glucometer** at the bedside for blood glucose measurements (i.e., one machine per side room, or minimum one machine per bay)

If a patient fulfills all 4 steps of this criteria, follow step 2

STEP 2.

Are There Any Reasons To Exclude Your Patient From Starting The Protocol?
Exclusions From The Protocol:

- Diabetic emergencies (diabetic ketoacidosis; nonketotic, hyperosmolar coma)
- No arterial cannula *in situ*
- Not expected to be in the ICU for three days or more
- No dedicated glucometer available (within the bay)
- No infusion pump available to deliver insulin or to deliver 50% glucose

If any step 2 criteria fulfilled, no intensive insulin therapy protocol

STEP 3.

Starting The Protocol:
Commence Insulin Infusion* At A Rate Determined By The Following Table:

		Target Range				
First blood glucose measurement (mmol/liter)	≤3.9	4.4–6.1	<6.1	6.1–8	8.1–12	>12.0
Starting insulin infusion rate** (unit/h)	Follow Step 5	0	0	1	2	3

* Insulin is administered by continuous IV infusion using insulin neutral human (Actrapid®) 50 IU in 50 ml 0.9% sodium chloride
** Insulin-dependent diabetics should always have a continuous minimum insulin infusion rate of ≥0.5 unit/h

Only measure blood glucose using a glucometer, not the gas machine

STEP 4.

How Should Blood Glucose (BG) Be Monitored?

i. Only measure BG using a glucometer
ii. Check BG 2 hourly. If BG stable and within the target range, measure 4 hourly, providing no significant clinical change, and no change in nutritional intake

iii. If any of the following occur, check BG 2 hourly until three consecutive values fall within the target range:

- any change in insulin infusion rate
- significant change in clinical condition
- initiation or cessation of vasopressor or steroid therapy
- initiation or cessation of renal replacement therapy
- initiation, cessation, or change of rate of nutritional support

iv. If BG <4.4 mmol/liter, measure at least every 60 min (see Step 5)

STEP 5.

How Is The Insulin Infusion Rate Adjusted?

- Use the computerized decision-support found in the "glycaemic control" screen on CIMS (this is based on the table below)
- If the CIMS system is unavailable, use the table below or discontinue insulin and the protocol
- **Never use the CIMS "glycaemic control' screen if the patient is not "on protocol"**

Blood glucose (mmol/liter)	Change rate of insulin infusion (unit/h)
<2.5	STOP INSULIN INFUSION. GIVE 50 ml 50% GLUCOSE (if no central line, give 125 ml of 20%); recheck BG every 15 min. After 1 h, recommence insulin according to the table in Step 3.
2.5–3.9	STOP INSULIN INFUSION. GIVE 25 ml 50% GLUCOSE (if no central line, give 60 ml of 20%); recheck BG every 15 min. After 1 h, recommence insulin according to the table in Step 3.
4–4.3	Reduce dose by 50%; measure BG every 30 min until BG >4.4 mmol/liter
4.4–6.1	**Target range** • If BG lower than last measurement – reduce by 1 unit/h • If BG lower by more than 50% of last measurement – reduce dose by 50% and check BG every 15 min (see Step 4) • If BG unchanged or higher than last measurement – no change
6.2–7.7	• If BG lower than last measurement – no change • If BG lower by more than 50% of last measurement – reduce dose by 50% and check BG every 30 min (see Step 4) • If BG unchanged or higher than last test – increase by 0.5 unit/h
7.8–11	• If BG lower than last measurement – no change • If BG lower by more than 50% of last measurement – reduce dose by 50% and check BG every 30 min (see Step 4) • If BG unchanged or higher than last test – increase by 1 unit/h
11.1–14	• If BG lower than last measurement – no change • If BG lower by more than 50% of last measurement – reduce dose by 50% and check BG every 30 min (see Step 4) • If BG unchanged or higher than last test – increase by 2 unit/h
≥14.1	Increase rate by 2 unit/h. If BG >14.1 for three consecutive tests, increase insulin rate by 50%, check BG every 30 min, and call Physician

The maximum insulin rate is 50 unit/hour. If this is reached and hyperglycemia is still evident, consult Consultant, Specialist Registrar, or Unit Pharmacist for advice.

STEP 6.

When To Stop Intensive Insulin Therapy Protocol?

- STOP INSULIN during any interruption to enteral or parenteral feeding (e.g., patient transfer to CT scan, prior to surgery, or aspiration during feeding protocol). If restarting the protocol, insulin should commence at the start of the protocol once feeding is reestablished (as per Step 3). If hyperglycemia develops, administer convention insulin therapy.
- If the patient's treatment and/or condition necessitates frequent interruptions to the protocol, discuss with Consultant or Nurse-in-Charge about protocol discontinuation
- Stop protocol four hours prior to patient transfer outside ICU, but continue to monitor blood glucose at least hourly
- Stop protocol if arterial cannula removed
- Stop protocol and revert to conventional insulin therapy (or preadmission diabetic therapy, if any) 24 h prior to discharge from ICU
- Do not stop protocol if patients are extubated, providing they have an arterial cannula in situ
- Stop protocol if patient requires glucose insulin potassium protocol (GIK) insulin regimen, but revert back to intensive insulin therapy protocol when GIK course finishes

Document all reasons for discontinuing the protocol in the notes