Nurse- vs Nomogram-Directed Glucose Control in a Cardiovascular Intensive Care Unit

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Background Paper-based nomograms are reasonably effective for achieving glycemic control but have low adherence and are less adaptive than nurses' judgment.
Objective To compare efficacy (glucose control) and safety (hypoglycemia) achieved by use of a paper nomogram versus nurses' judgment.
Methods Prospective, randomized, open-label, crossover trial in an intensive care unit in postoperative patients with glucose concentrations greater than 8 mmol/L. Consenting nurses with at least 1 year of experience were randomized to use either their judgment or a validated paper-based nomogram for glucose control. After completion of 2 study shifts, the nurses used the alternative method for the next 2 study shifts. Glucose target level and safety and efficacy boundaries were the same for both methods. The primary end point was area under glucose time curve per hour.
Results Thirty-four nurses contributed 95 shifts of data (44 nomogram-directed, 51 nurse-directed). Adherence to the nomogram was higher in the nomogram group than hypothetical adherence in the nurse-directed group for correct adjustments in insulin infusion (70% vs 37%; $P < .001$) and glucose checks (58% vs 43%; $P = .008$). The primary end point did not differ between the 2 groups (mean, 9.0 mmol/L; SD, 3.5 vs mean, 8.3 mmol/L; SD, 2.1; $P = .08$). Glucose variability, amount of time patients were hypoglycemic or hyperglycemic, and number of glucose checks performed were similar in the 2 groups.
Conclusions In an intensive care unit where nurses generally accepted the need for tight glucose control, nurse-directed control was as effective and as safe as nomogram-based control. (*American Journal of Critical Care.* 2012;21:270-279)

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Infusion of medications in acute care is routine. Nomograms such as those using activated partial thromboplastin time for heparin infusions[1,2] or blood glucose levels for insulin infusions[3-6] allow nurses to titrate medications to achieve predefined target therapeutic responses. Compared with traditional nonstandardized dosing by physicians, use of the nomograms results in faster or more frequent achievement of targets. Use of intensive insulin therapy in critically ill patients has been extensively evaluated after a landmark trial in surgical patients indicated improved mortality with such therapy.[7,8] Since then, numerous studies have validated use of various paper-based[6] or computer-based[9-11] nomograms that standardized the approach to blood glucose control. Although the optimal target level of blood glucose remains controversial, subsequent trials have shown that achieving tight control is extremely difficult, even in clinical trials with specific protocols,[12,13] and requires considerable nursing time.[14] Indeed, with many nomograms, 8 to 12 hours is required to achieve the target blood glucose level, the target range is maintained only 75% of the time at best, and nurses' adherence to use of the nomograms is poor.[6,15-18] The task is difficult because blood glucose control depends on numerous rapidly changing and interrelating factors.

Importantly, in the Leuven I trial,[19] blood glucose control was achieved by a dedicated team that used a set of general guidelines that allowed latitude for clinicians' expertise. This type of dedicated expertise is not available outside a clinical trial and thus limits the generalizability of the results. However, the results do indicate that nomograms may not always be necessary. Moreover, for infusion of other medications such as vasopressors or inotropes, nurses have traditionally been responsible for titrating the dosages to achieve prespecified goals (eg, blood pressure, cardiac output, mixed venous oxygen saturation) without the use of prescriptive nomograms or computer technology. This approach has several potential advantages. First, nurses are continuously available and are more familiar than other health care providers with patients' characteristics and responses to current therapies. Second, nurses have experience and receive training in titrating doses of infused medications with narrow therapeutic indices. Third, nurses are more able than other providers to respond proactively to a patient's rapidly changing needs. Fourth, no additional technology is required at the bedside in an already busy intensive care unit (ICU). Finally, this approach increases nurses' autonomy, a concept that has been associated with increasing their perceptions of improved quality of care and job satisfaction.[20] However, a possible disadvantage of this approach is that it may hinder standardization of therapies.

O'Connor et al[21] compared the nurse-directed approach with nonstandardized physician-directed sliding scales in a retrospective study of glucose control in the ICU. The findings indicated that nurse-directed control may result in marked improvement in blood glucose levels. Because of the limits of this type of study design, we conducted a randomized controlled trial comparing the efficacy (ie, glucose control and variability) and safety (ie, hypoglycemia) of nurse-directed insulin therapy with a validated paper-based nomogram-directed insulin therapy for achieving blood glucose targets in patients in our cardiovascular ICU.

Methods

The investigation was a prospective, randomized, crossover study conducted in an adult 13-bed

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cardiovascular ICU at St Michael's Hospital, Toronto, Ontario, an urban tertiary-care academic hospital. The study protocol was approved by the hospital's institutional research ethics board and was registered at www.clinicaltrials.gov (NCT 00636714).

Nurse-directed insulin therapy was compared to a paper-based nomogram-directed therapy.

Participants

All nurses of the cardiovascular ICU who had at least 1 year of experience and were working regular clinical shifts were invited to participate in the study. Those who consented were randomly assigned to 1 of the 2 study arms by using concealed envelopes, stratified by years of experience (1-3 years, >3 years). The randomization sequence was generated by using random block sizes of 4 or 6, and the sequentially numbered sealed opaque envelopes were generated by a third party not involved in either the care of the patients or the study operations.

The standard of practice in the ICU (patient to nurse ratio 1 to 1) was to use the validated insulin nomogram[5] for any postoperative patient whose blood glucose level was greater than 8 mmol/L (to convert to milligrams per deciliter, divide by 0.0555). Therefore, consecutive patients who were recently (within 24 hours) admitted to the ICU whose blood glucose concentration was greater than 8 mmol/L and whose nurse had consented to participate were included. This restricted time frame was used because achieving blood glucose targets would be the most difficult immediately after ICU admission. Each ICU nursing shift was 12 hours long; however, data for each shift may be for less than 12 hours, depending on when the insulin infusion was actually started or when the patient was discharged from the ICU. Each patient could be a source of data for up to a maximum of 3 shifts. Exclusion criteria were as follows: diabetic ketoacidosis, plan by clinical team to withdraw supportive care, enrollment refusal by the attending physician, and patient's allergy to human insulin.

Nurses completed 4 shifts in the study, 2 adhering to the nomogram, 2 using their judgment to titrate insulin.

Intervention

Each nurse who consented to participate was expected to complete up to 4 shifts within the study. For 2 shifts, the nurses were to strictly adhere to the existing validated insulin nomogram, in use since 2006, for titrating insulin infusion and frequency of checking glucose levels; the target level was 5 to 8 mmol/L. The data from these shifts were assigned to the nomogram-directed group. For the other 2 shifts, the nurses were to use their experience and judgment in performing glucose checks and titrating an insulin infusion to maintain the same blood glucose target range. Designated the nurse-directed group, they had boundaries for safety and efficacy similar to those for the nomogram-directed group for contacting a physician for reassessment. The nomogram target was higher than the 4.4 to 6.1 mmol/L used in the Leuven trial because of local concerns about hypoglycemia. Repeated internal quality assurance audits indicated that mean blood glucose levels achieved throughout the ICU stay by using the nomogram were consistently between 7 and 8 mmol/L and thus justified the decision to continue using the nomogram despite the reported harm in the tight target group in the NICE-SUGAR (Normoglycemia in Intensive Care Evaluation–Survival Using Glucose Algorithm Regulation) study.[13] Blood glucose concentrations were determined by using capillary blood and bedside glucometers.

At the time of enrollment, nurses were randomized to complete their first 2 study shifts as nomogram directed and the next 2 shifts as nurse directed or to complete the first 2 shifts as nurse directed and the next 2 shifts as nomogram directed. No attempts were made to change the method of assigning patients to individual nurses or to other aspects of ICU care. The insulin infusions for both arms of the study were prepared in an identical manner by using recombinant human rapid-acting insulin (Humulin R, Eli Lilly and Co, Indianapolis, Indiana).

Data Collection

Baseline demographic and clinical information, Acute Physiology and Chronic Health Evaluation II scores, and use of corticosteroids and parenteral nutrition were documented for each patient. Glucose control, insulin administration, and concomitant glucose sources were documented for each eligible shift. The primary end point of the study was glucose control as indicated by the mean hourly area under glucose time curve. This end point takes into account the different contribution of each shift in terms of number and frequency of blood glucose sampling and the duration of insulin therapy. Secondary end points included mean glucose concentration per shift, proportion of time blood glucose level was less than, more than, and within the target range, proportion of time blood glucose level was in the hypoglycemic (<4 mmol/L) and hyperglycemic (>10 mmol/L) ranges, and the number of glucose measurements. In addition, 3 different measures of glucose variability, namely, standard

deviation, coefficient of variability, and mean absolute glucose levels previously described for critically ill patients were calculated.[22-24]

Adherence to the nomogram was assessed independently by 2 investigators (C.C. and J.O.F.); discrepancies were resolved via consensus. Each glucose measurement was assessed independently for both adherence to adjustments in insulin infusion rate and the timing of the next glucose measurement. This assessment was done for both the data shifts in which a nurse was assigned to the nomogram arm and for hypothetical adherence for the data shifts in which the nurse was assigned to the nurse-directed arm (ie, comparing what the nurse actually did with what the nomogram would have instructed the nurse to do). This step was taken to determine whether the 2 arms of the intervention differed from each other; all nurses had previously used the nomogram, and potential for a carryover effect existed.

The area under the curve was calculated by using the trapezoidal rule. All data shifts were used in the analysis regardless of duration. Because each nurse worked a different number of shifts in a different order and some data were available for some patients for more than 1 shift, the generalized estimating equation[25] was used to compare the 2 study intervention groups to account for clustered data due to the different number of data points contributed by each nurse. A Gaussian model was used for continuous variables; a Poisson model with the logarithm of shift length used as the offset was used for count variables. The models were fitted by using an exchangeable correlation structure. All models are adjusted for shift, nurse's experience, and initial group assignment (ie, whether the nurse started with nomogram or experience first). Statistical calculations were carried out by using R software, version 2.11.1 (R Project for Statistical Computing, Vienna University of Economics and Business, Vienna, Austria).

A sample size (disregarding the effects of clustering) was calculated on the basis of the results of a previous study[5] in which the standard deviation in blood glucose level was 1.8 mmol/L. Use of 2-sided α and β values of .05 and .20, respectively, and a clinically relevant difference in a blood glucose value of 1.0 mmol/L, indicated that approximately 51 shifts of data per group would be needed in each arm of the study.

Results

The trial was conducted between February 2008 and April 2010. Of the 77 nurses on staff during the period, 40 met inclusion criteria, and 38 of the 40 consented to participate (Figure 1). These 38 nurses had a mean experience of 13.5 years (SD, 8.7; range, 2-29). Four nurses who consented to participate did not contribute any data because they could not match their working shifts with eligible patients. The remaining 34 nurses contributed a total of 95 shifts worth of data, with a mean of 2.8 shifts per nurse. Because of staff turnover and the increasing difficulties of matching participating nurses who had not completed all 4 shifts to eligible patients, the study was terminated at 95 shifts. A total of 18 nurses (47%) completed all 4 shifts. Of the 95 shifts, 51 (54%) were nurse directed, and 42 (44%) occurred during the day. Nurses assigned to begin with nomogram-directed glucose control had significantly more years of experience ($P = .01$) than did the other nurses. The 95 shifts worth of data were collected from 83 individual patients, 10 of whom provided data for 2 shifts and 2 for 3 shifts. Table 1 outlines the contribution of data from each nurse. The demographics of the enrolled patients are outlined in Table 2. No patients were excluded because of refusal by their attending physicians.

> The amount of time per shift when blood glucose was within the target range was similar between the 2 groups.

Nomogram Adherence

The actual adherence by nurses during nomogram shifts and hypothetical adherence to the nomogram during nurse-directed shifts to both frequency of glucose checks and adjustments in insulin infusion are presented in Table 3. The ratio of the number of adjustments in insulin infusions performed correctly per shift in the nomogram-directed group was significantly higher than in the nurse-directed group (ratio, 2.10; 95% CI, 1.54-2.88; $P < .001$). Similarly, the ratio of the number of glucose checks performed correctly per shift was significantly higher in the nomogram-directed group than in the nurse-directed group (ratio, 1.43; 95% CI, 1.10-1.87; $P = .008$). Glucose checks performed at incorrect intervals were classified as more often or less often than prescribed by the nomogram instructions. The nomogram-directed group was significantly less likely than the nurse-directed group to perform the glucose checks less often than prescribed (ratio, 0.69; 95% CI. 0.56-0.86; $P < .001$). The number of times per shift that the glucose checks

> Frequency of glucose checks was lower in the nurse-directed group, but not significantly.

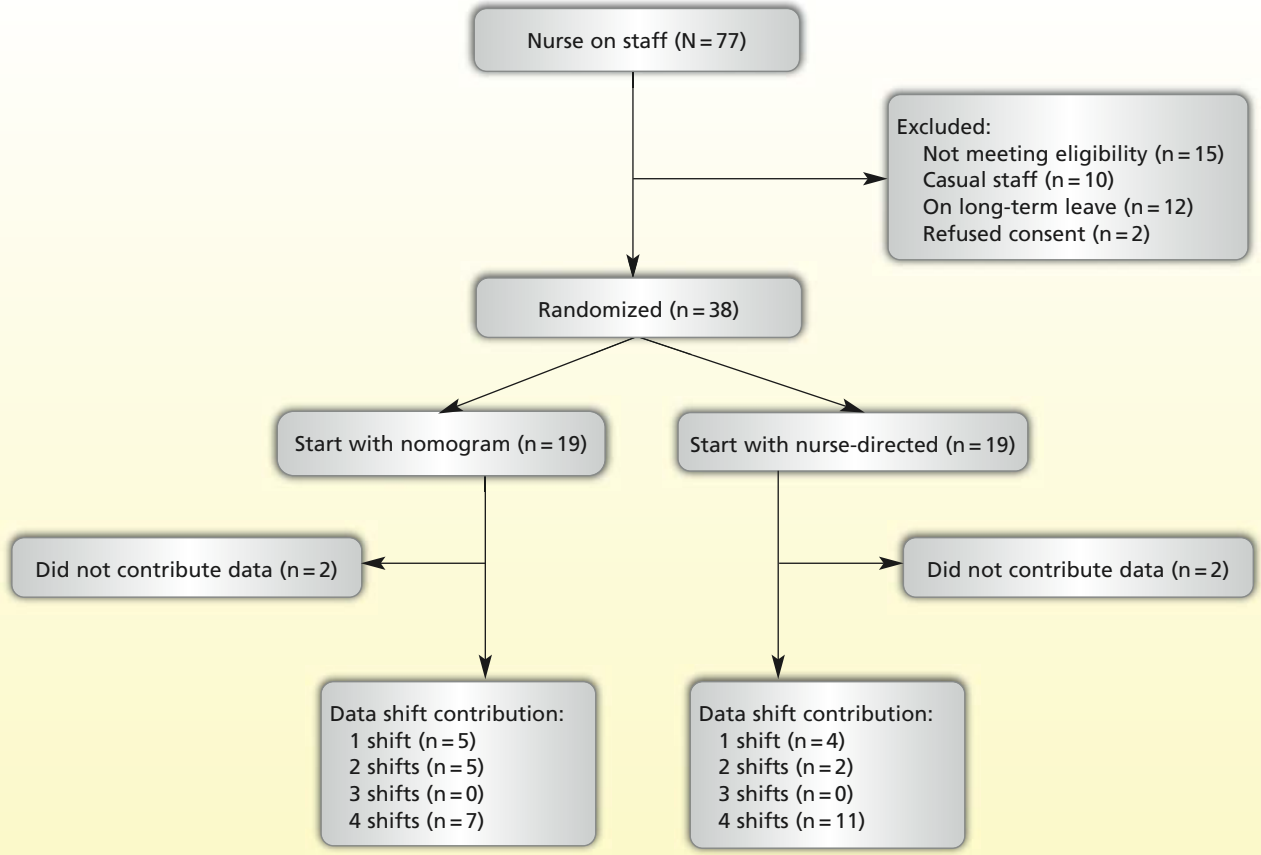

Figure 1 CONSORT diagram for flow of participants through study.

Table 1
Demographics of participating nurses

Characteristic	No. of nurses	
	Nurse directed, then nomogram	Nomogram, then nurse directed
Shifts worked		
0	2	2
1	5	4
2	5	2
3	0	0
4	7	11
Day shift	17	25
Evening shift	26	27
Experience, mean (SD), y	11.3 (8.5)	16.3 (8.4)

were done more often did not differ between the 2 groups (ratio, 0.97; 95% CI, 0.52-1.80; $P = .91$)

Glucose Control

Crude glucose control in both nomogram- and nurse-directed groups is depicted in Figure 2, and the comparisons between the 2 groups are presented in Table 4. For the primary end point of glucose control, the mean hourly area under the glucose time curve did not differ between the 2 groups. The mean blood glucose concentration was also similar between the 2 groups. Because these mean levels, measured within 24 hours of the start of using the nomogram for hyperglycemia, were greater than the nomogram target of 5 to 8 mmol/L, we also calculated the mean glucose concentration for each group by using the last available glucose value for each shift (mean, 7.4; SD, 2.1 and mean, 7.9; SD, 2.1, mmol/L for the nurse- and nomogram-directed groups, respectively; $P = .24$) to better gauge the effectiveness of both the nurse- and the nomogram-directed interventions. The proportion of time within each shift when a patient's blood glucose level was within the target range (5-8 mmol/L), greater than the target range, less than the target range, hyperglycemic (>10 mmol/L), and hypoglycemic (<4.0 mmol/L) were also similar between the 2 groups, as was variability in glucose concentration calculated by using 3 previously published methods (see Table 4).

Overall, the mean number of glucose checks performed per hour for the nomogram- and

nurse-directed groups was 0.76 (SD, 0.39) and 0.62 (SD, 0.16), respectively (Table 3). Although the frequency of glucose checks tended to be lower in the nurse-directed group, the difference was not significant ($P = .06$).

Discussion

Our results indicate that nomogram-directed adjustments in insulin infusions were no better than adjustments based on nursing judgment for glucose control, glucose variability, patients' safety, and nurses' workload. This conclusion was made on the basis of the finding that the 2 groups differed significantly in terms of their approach to glucose control (ie, real or hypothetical adherence to the nomogram). Time patients spent at various ranges of blood glucose levels, overall variability in blood glucose level, and frequency of blood glucose checks did not differ significantly between the 2 groups.

So far as we know, our investigation is the first randomized controlled study in which a prescriptive method of titrating medication was compared with titrating based on nurses' experience. At first glance, our results seem somewhat counterintuitive because standardization of care through the use of nomograms can reduce variability and improve patients' outcomes.[1-6,9,10] However, studies with medications such as heparin are not subjected to as many confounding factors, and nomogram-directed heparin titration was compared with traditional physician-directed therapy.[1,2] This traditional method did not empower nurses to use their knowledge and experience and thus did not improve autonomy. Similarly, previous studies[3-6,9,10] validating use of various published paper nomograms for adjustments in insulin dosing mostly compared the nomogram-directed adjustments with changes based on the use of traditional sliding scales or on usual care in which nurses had to contact a physician for insulin orders based on the results of glucose measurements, a practice that differs from the intervention in our study. More commonly, ICU nurses are allowed to titrate medications such as vasopressors in this autonomous manner rather than through the use of defined nomograms. As previously stated, general rules for titration and expertise of study physicians or nurses rather than an explicit rigid algorithm were used in the Leuven study to successfully achieve the tight glucose control targets.[19] Because patients differ in their sensitivity to the same dose of insulin, and because many dynamic conditions affect glucose control in the ICU, it is not surprising that a rigid paper-based nomogram is not suitable for every patient. Computer-based programs that can be adapted for each patient have been developed and validated.[11] However, the cost-effectiveness and logistics of such technology at a busy bedside have not been well evaluated, and the technology may not be desirable, especially because tight glucose targets may not be beneficial.

Table 2
Demographics of participating patients[a]

Characteristic	Nurse directed, then nomogram	Nomogram, then nurse directed
Age, mean (SD), y	65 (14)	67 (12)
Sex		
Male	30 (70)	38 (73)
Female	13 (30)	14 (27)
APACHE II score, mean (SD)	14 (5)	13 (4)
Body mass index,[b] mean (SD)	28.0 (5.0)	28.7 (5.2)
Diabetes mellitus	14 (33)	31 (60)
Operative procedure		
Bypass	17	30
Valve replacement	4	12
Bypass and valve replacement	6	2
Arch repair	4	2
Bentall procedure	3	3
Other[c]	9	3
Parenteral nutrition	1	0
Use of corticosteroids	1	3

Abbreviation: APACHE, Acute Physiology and Chronic Health Evaluation.
[a] A total of 95 shifts of data were collected in 83 individual patients, 10 of whom contributed 2 shifts and 2 of whom contributed 3 shifts. Values are number (percentage) of patients unless otherwise indicated in first column.
[b] Calculated as the weight in kilograms divided by the height in meters squared.
[c] Myxoma, dissection, embolectomy, thoracic endovascular aortic repair.

Table 3
Adherence to nomogram

Indicator[a]	Nomogram-directed group (n = 44)	Nurse-directed group (n = 51)	*P*[b]
Infusion changes in accordance with nomogram, %	70.2	36.6	<.001
Glucose check frequency in accordance with nomogram, %	57.7	42.7	.008
Less often than prescribed	22.5	32.4	<.001
More often than prescribed	19.8	24.8	.91
Glucose checks, mean (SD)			.06[c]
Mean number/patient shift	5.9 (2.2)	5.5 (1.5)	
Mean number/hour	0.76 (0.39)	0.62 (0.16)	

[a] See Methods section for explanations.
[b] *P* values correspond to comparisons of the number of changes in insulin infusion or blood glucose checks between groups, after accounting for clustering by using the generalized estimating equation model. See text for ratios and confidence intervals.
[c] *P* value refers to comparison of mean number of glucose checks per hour.

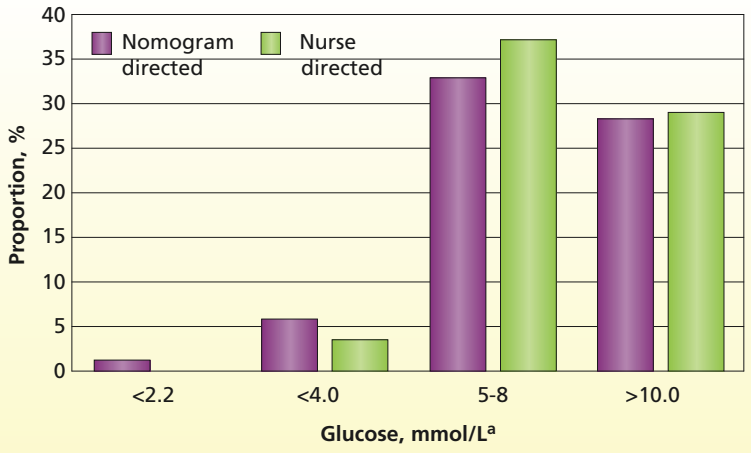

Figure 2 Glucose distribution between the 2 groups.

[a]To convert to milligrams per deciliter, divide by 0.0555.

Table 4
Glucose control

Parameter	Nomogram-directed group (n = 44)	Nurse-directed group (n = 51)	*P*[a]
Hourly blood glucose area under curve, mean (SD), mmol/L	9.0 (3.5)	8.3 (2.1)	.08
Blood glucose level, mean (SD), mmol/L	8.4 (1.9)	8.5 (2.0)	.51
Time spent at blood glucose level, mean (SD), min			
Below target (<5 mmol/L)	8.9 (17.1)	8.0 (18.4)	.43[b]
Within target (5-8 mmol/L)	34.3 (29.7)	41.6 (31.8)	.12
Above target (>8 mmol/L)	57.3 (36.1)	50.6 (35.4)	.08
% of time			
Hypoglycemic (<4 mmol/L)	3.4 (7.8)	2.2 (8.6)	.77[b]
Hyperglycemic (>10 mmol/L)	21.1 (31.3)	25.9 (32.3)	.82[b]
Glucose variability[c]			
Shift standard deviation, mean (SD), mmol/L	1.81 (0.94)	1.87 (0.94)	.07
Coefficient of variation, mean (SD), %	22.3 (12.8)	22.5 (10.7)	.17
Mean absolute glucose, mean (SD), mmol/L per hour	0.92 (0.66)	0.82 (0.58)	.96

[a] After clustering was accounted for by using the generalized estimating equation regression model.
[b] For these outcome variables, the residuals displayed a clear lack of normality. Therefore, P values should be interpreted with caution.
[c] Shift standard deviation is the standard deviation of all measured glucose values within a shift. Coefficient of variation is the standard deviation divided by the mean per shift. Mean absolute glucose is the sum of all absolute glucose changes each shift divided by the total time per shift.

We think that our previous efforts during the time the nomogram was validated changed the culture of our nurses from the old model of not treating hyperglycemia until metabolic complications arose to the need to maintain normoglycemia. This change in culture has further enabled nurses to exercise their judgment and potentially lessened the need for rigid paper tools. Finally, paper-based nomograms do not increase autonomy; they are merely another form of written prescription.[26] For bedside nurses, autonomy in clinical practice is an action beyond the usual standard of nursing practice that results from clinical competence, specialized knowledge, and critical thinking. In a large study[20] of 279 nurses, clinical autonomy was the third most important factor for the delivery of quality care. In addition, autonomy is significantly correlated with job satisfaction.[27] Our use of an autonomous approach has implications and applicability beyond titration of insulin infusions; infusions of many other drugs (eg, diuretics) could be managed in an analogous manner.

In our study, nurses' adherence to the paper nomogram was moderate at best, consistent with findings of other investigators[16,17] and our earlier work.[18] Cyrus et al[16] reported adherence rates of 68% for infusion changes and 26% for glucose checks, Malesker et al[17] reported a poor adherence rate of 25%. However, although adherence was moderate in those studies,[16-18] glucose control was attained. Most likely nurses are already using their clinical judgment to some extent when they decide that nomogram instructions are unsuitable for a particular patient even when the nomogram was prescribed. This practice further lends support to the idea that once the culture has been changed, allowing nurses to exercise their professional judgment in a complex situation would be as effective and as safe as using a rigid paper-based nomogram.

Because of the design of our study, our finding that the mean glucose levels were slightly greater than the upper limit of the target range of 5 to 8 mmol/L for both groups was not unexpected. All shifts were started within 24 hours of nomogram initiation for hyperglycemia. In our previous validation of the nomogram,[5] the median time to attain 2 consecutive blood glucose values within the target range was 15 hours. Consequently, because the study shifts were at most 12 hours long, many of the mean shift blood glucose values most likely would be greater than the target range. Indeed, the effectiveness of the nomogram in our study is indicated by the finding that on average by the end of a shift, blood glucose values were already within the target range.

In the previous retrospective study, O'Connor et al[21] compared the efficacy of nurse-directed glucose control with that of a nonstandardized control group of ad hoc sliding scales written by different physicians.

The retrospective nature, some important differences in baseline characteristics, and the use of a nonstandardized control group limit the generalizability of the results. Although O'Connor et al reported a significantly lower blood glucose level in the nurse-directed group, the clinical relevance of a reduction of 0.5 mmol/L in mean blood glucose concentration is unclear.

Our study had several limitations. First, it was conducted in a single hospital that had already achieved a culture change regarding the importance of glucose control. Thus, our results may not be generalizable to other cardiovascular ICUs with less acceptance of the importance of glucose control or less experienced nursing staff. Second, only half of the enrolled nurses completed 4 shifts. Because of the difficulty in recruiting nurses for the remaining shifts, a change in practice by our anesthesiologist to institute intraoperative blood glucose control during the study period, and the newer data on the issue of intensive glucose control, we considered it appropriate to cease enrollment.

The lack of completion of all 4 shifts means that only about half of the nurses could act as their own controls and reduces statistical power to detect differences between methods. For example, with increased numbers of shifts, the lower number of glucose checks in the nurse-directed group might have been significant. However, the absolute values of the various glucose control measurements were extremely similar, suggesting that even if we had more study shifts, we most likely would be unable to detect clinically meaningful differences between methods for these measures. We used the generalized estimating equation to account for the different contributions of different nurses, a step that strengthens our analysis and conclusions. Finally, despite attempts to enforce strict adherence to the nomogram by nurses assigned to the nomogram arm of the study, the overall adherence was only 58%. This percentage, however, was similar to that reported by other researchers.[16-18] Nevertheless, adherence was significantly higher in the nomogram-directed group than in the nurse-directed group, suggesting that the 2 groups did use different methods to direct glucose control even though the same group of nurses was involved in both arms of the study and all had previously used the nomogram. We also did not formally assess nursing satisfaction due to the increased autonomy. Finally, although allocation to group assignment was concealed for the first nursing shift within the study, nurses completing more than 1 study shift became aware of their assignment for the remaining shifts.

Conclusions

Use of nursing judgment and experience compared with use of a nomogram to titrate insulin produced the same quality of glucose control without adversely affecting patients' safety in a group of ICU nurses who had been previously educated about and accepted the need for tight glucose control. Because of the limitations of fixed nomograms and the potential to improve patient care and nurses' satisfaction and autonomy, this approach merits further investigations on titration of insulin and other medications that require frequent dose adjustments.

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CNE Test

Test ID A1221042: Nurse- vs Nomogram-Directed Glucose Control in a Cardiovascular Intensive Care Unit.

Learning objectives: 1. Review purpose of nomogram use in control of blood sugar in intensive care unit patients. 2. Examine objective and methods of this research study. 3. Determine usefulness of this study in your work setting.

1. Which of the following statements best describes the purpose of a nomogram?
a. Allows for nurses to prescribe effective medications
b. Allows nurses to titrate medications to achieve predefined targets
c. Identifies only physicians to titrate insulin
d. Identifies which nurses can titrate insulin in emergency situations

2. Which of the following differences is seen when comparing nomograms to nonstandard dosing by physicians?
a. Faster and more frequent achievement of targets with nomograms
b. Faster and more frequent achievement of targets by physician dosing
c. Faster but less frequent achievement of targets with nomograms
d. Faster but less frequent achievement of targets by physician dosing

3. How many hours are usually required to achieve the target blood glucose level using nomograms?
a. 1 to 4 hours
b. 5 to 8 hours
c. 8 to 12 hours
d. More than 13 hours

4. Which of the following statements is not true?
a. Nurses are continuously available and more familiar with patients' characteristics.
b. Nurses have experience and receive training in titrating doses of infused medications to narrow therapeutic indices.
c. Nurses' autonomy is decreased, which provides more job satisfaction.
d. Nurses respond proactively to a patient's changing needs.

5. Which of the following patients were enrolled in this study?
a. Patients with trauma
b. Postoperative cardiovascular patients
c. Patients with diabetic ketoacidosis
d. Patients who had a renal transplant

6. What was the patient to nurse ratio in the intensive care unit (ICU) studied?
a. 1:1
b. 1:2
c. 2:1
d. 3:1

7. Which of the following statements is not true?
a. Nurses could participate if they had more than 1 year of experience.
b. Nurses could participate if they were on orientation to the unit.
c. Nurses could participate if they worked regular shifts.
d. Nurses could participate if they had 3 or more years of experience.

8. Which of the following statements is not true?
a. Nurses were expected to complete up to 4 shifts in the study.
b. For 2 shifts nurses would follow the nomogram; for 2 shifts they would titrate based on experience.
c. The primary end point of the study was glucose control.
d. The nomogram target was lower because of concerns about hyperglycemia.

9. Which of the following was not part of the study's findings?
a. The ratio of correct adjustments of infusions was higher in the nomogram group than nurse directed group.
b. The nomogram group was significantly less likely to perform glucose checks less often.
c. The ratio of glucose checks performed correctly was higher in the nomogram group.
d. The ratio of correct adjustments of infusions was higher in the nurse directed group than nomogram group.

10. Which of the following statements best reflects the findings in regard to the primary end point of this study?
a. The mean hourly area under the glucose time curve was significantly different for the nurse directed group.
b. The mean hourly area under the glucose curve was significantly different for the nomogram group.
c. The mean hourly area under the glucose curve was not studied in this research project.
d. The mean hourly area under the glucose curve did not differ between the 2 groups.

11. Which statement best describes the findings of the study?
a. Nomogram adjustments were significantly better than nurse directed adjustments when considering glucose variability.
b. Nurse directed adjustments were significantly better than nomogram adjustments when considering patient safety.
c. There was no significant difference between nomogram and nurse directed adjustments for glucose variability and nurses workload.
d. Time patients spent at various ranges of blood glucose control differed significantly in favor of nomograms.

12. Which of the following was a limitation of the study?
a. The hospital had not used glucose control nomograms in past.
b. All enrolled nurses completed all 4 shifts required for the study.
c. Achievement of culture change regarding importance of glucose control may be less generalizable to other ICUs.
d. All nurses enrolled in the study achieved strict adherence to nomogram.

Test ID: A1221042 Contact hours: 1.0 Form expires: July 1, 2014. **Test Answers:** Mark only one box for your answer to each question. You may photocopy this form.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a	❑a
❑b	❑b	❑b	❑b	❑b	❑b	❑b	❑b	❑b	❑b	❑b	❑b
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❑d	❑d	❑d	❑d	❑d	❑d	❑d	❑d	❑d	❑d	❑d	❑d

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