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Efficacy of Nurses Led Insulin Protocol to Control Blood Glucose among Critically Ill Patients

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Abstract

Aim and objectives: This study aimed to determine the efficacy of nurse led insulin protocol to control blood glucose among critically ill patients.

Background: Hyperglycemia is a common problem among critically ill patients in the ICUs that consistently linked with worsened clinical outcomes in various groups of patients. Thus, ensuring effectiveness, safety and a high-quality glycemic control can be achieved with a protocol that combining continuous intravenous insulin with frequent bedside blood glucose monitoring.

Design: Quasi-experimental design was used in this study.

Methods: This study was conducted in the ICU departments at Alexandria Main University Hospital on 60 newly admitted hyperglycemic critically ill patients. They randomly assigned into two groups; control group and intervention group. The nurse led insulin protocol was applied among the study group, while the control group managed by the routine ICU management.

Results: The hyperglycemic mechanically ventilated patients who were managed by the nurse led insulin protocol experienced lower mean blood glucose level and lower glucose variability than those who were managed by routine management of the ICUs.

Conclusion: The nurse led insulin protocol was an effective to control blood glucose level among critically ill patients. Relevance to the clinical practices: nurses' led insulin protocol has strongly and consistently linked with better glycemic control and improved clinical outcomes in various groups of patients. Implementation of nurse led protocols increases nurses' autonomy; a concept that has been associated with increasing their perceptions of improved quality of care and job satisfaction.

Keywords: Hyperglycemia; Glycemic control; Nurse led protocol

Introduction

Alteration of blood glucose (BG) in the ICUs described by the critical induced CID, which involve various states of glucose dys-regulation, such as hyperglycemia, hypoglycemia, and glucose variability [1-3]. It occur because of a combination of increased production of catabolic hormones, excessive inflammatory mediators, counter regulatory hormone, increased hepatic gluconeogenesis, and resistance to the peripheral and hepatic actions of insulin [4]. A nurse led protocol is one in which the nurse initiate the detailed plan of the medical/ nursing treatment according to a set plan. They have been shown to improve patient care outcomes. Protocol combining continuous intravenous insulin with frequent bedside blood glucose monitoring is essential for successful implementation of intensive insulin therapy [5].

Background

Growing body of evidence during the past decade indicated that uncontrolled blood glucose among critically ill are associated with adverse outcomes. Stressful medical interventions; mechanical ventilation, administration of corticosteroids, vasopressors, dextrose solutions, enteral or parenteral nutrition, which aggravate hyperglycemia [6].

Uncontrolled BG associated with increased mortality and morbidity in a variety of critical settings, increased rate of infections, disturbed wound healing, increased LOS, prolonged mechanical ventilation, and poor prolonged functional outcomes [7,8]. Thereby, critically ill patients requiring intense glycemic control, monitoring, and vigilant nursing care [9].

Insulin is the most potent anabolic hormone regulates the metabolism of carbohydrates, lipids and protein. It mainly transports the glucose into the cell, through enriching the concentration, and increase recycling of facilitative glucose transporter Glut4 at the plasma membrane [10]. In addition, insulin stimulate the action of the microtubule network and actin cytoskeleton that play role in Glut4 trafficking, either by linking signalling components or by directing movement of vesicles from the peri-nuclear region to the plasma membrane [11].

A prospective randomized controlled trial conducted at Catholic University of Leuven, Belgium (2006) which involving 1548 patients admitted to a surgical ICU revealed that intensive insulin therapy (IIT) targeting BG concentration of 4.4–6.1 mmol/L (80-110 mg/dl), significantly reduced in-hospital mortality rate. However, not all patients exhibit benefits from IIT regimen, the clearest benefits demonstrated for surgical ICU patients. Then in 2009; NICE-SUGAR study has reported increased episodes of hypoglycemia in medical ICU when strict intensive insulin therapy has been applied. The study demonstrated that moderate BG level 140-180 mg/dl is associated with lower mortality and lower risk of hypoglycemia when compared to strict glucose target [12]. Thus, the target range of 4.4–6.1 mmol/l (80-110 mg/dl) no longer universally recommended due to the high risk of hypoglycaemia [13].

Definitely, effective protocols need multidisciplinary team collaboration among critical care providers. In this area; several studies reported that nurse driven protocol is an effective approach of utilization of evidence base practice [14-17]. Moreover, algorithms has designed and standardized to meet the needs of a multidisciplinary team, including physicians, nurses, pharmacists, and specialists [18].

Nurses led insulin protocol of insulin has several potential advantages; continuous availability of the nurses at patients' bedside, the nurses are more familiar than other health care providers with patients' characteristics and responses. However a multidisciplinary team and other medical staff must be involved, it still titled as a nurse-led protocol. Moreover, nurses have experience and receive training in titrating doses of infused medications, and able than other providers to respond proactively to a patient's rapidly changing needs. This approach increases nurses' autonomy; a concept that has been associated with increasing their perceptions of improved quality of care and job satisfaction [19].

Aim of the study

The aim of the present study was to determine the efficacy of nurse led insulin protocol to control blood glucose among critically ill patients.

Subjects and Methods

Design and settings

The quasi experimental design has been utilized in this study. This study carried out at Alexandria main university hospital, three ICUs were involved in the study. Casualty care unit (unit I) which chiefly receive traumatic patients from emergency department, the unit II which receive patient from other departments of the hospital, and general ICU (unit III) which receive patient from other hospitals.

Subjects

A sample size calculation of sixty adults patients who newly admitted into the previous mention departments during the period between March to December 2016 were involved according preset inclusion criteria: more than 18 years old and hyperglycemic (BG ≥ 180 mg/dl). Elderly patient >70 years, and patient who admitted due to hyperglycemic emergency reasons (e.g., DKA) and patient who underwent hemodynamic instability were excluded from the study's sample. The enrolled patients were randomly assigned into two groups (30 patient in each).

Data collection tool

The Hyperglycemic critically ill patient's assessment record has developed by the researcher after reviewing the related literature [20-23], and reviewed by 7 experts in the field of critical care nursing and critical medicine. It was consist of two parts; part I the Hyperglycemic critically ill patients' characteristics which used to collect demographical and clinical data of both groups. Part II of the tool "Blood glucose monitoring record" which used to document the blood glucose values of both groups all around the period of the study. For the study group this part of the tool also used to document adjustment of the insulin doses.

Pilot study

A pilot study was conducted out about 10% of the calculated sample size. The appropriate modification were done, and the pilot sample were excluded from the study sample.

Study maneuver

Newly admitted adult critical ill patients who met the inclusion criteria were randomly assigned into two equal groups, group A; the control group who were managed by the routine management of the ICUs. Group B; the intervention group who were managed by the nurse led insulin protocol (Box 1). For both groups; the patients' characteristics: demographic data and clinical data were obtained upon admission and recorded in the part I of the tool.

General guideline of the nurse led insulin protocol:
- Target blood glucose: (BG) 110-149 mg/dl
- Permissive hyperglycemia: 150-180 mg/dl
- Hyperglycemia: BG > 180 mg/dl
- Hypoglycemia: BG ? 70 mg/dl

Intravenous insulin administration: 50 IUs regular insulin/50 ml of 0.09% NaCl

Initiating infusion:
- All patients start in algorithm 0
- Insulin infusion is started when two consecutive BG level are = 150 mg/dl, or when one BG measurement is = 200 mg/dl.
- Patients should receive calories before insulin infusion (IV dextrose, TPN, or EN).

Moving from algorithm to algorithm
- *Moving up*: when BG levels increased by at least 40 mg/dl between two consecutive measurements, or when BG remains unchanged for the last two consecutive measurements.
- *Moving down*: when BG decreased by at least 40 mg/dl between two consecutive measurements.
- *Maintenance*: if BG continue to remain within the desired range (110-149 mg/dl)

Holding/discontinuing intravenous insulin infusion If tube feeding therapy is discontinued for any reason or If BG ? 110 mg/dl

Monitoring of the patients
- Check BG level each hour in the first 8 hours of initiating the insulin protocol, and then every two hours within target range for 8 hours.
- Decrease frequency of measurement to every 4 hours if patient's BG level is within the target range for 8 hours.
- Measure blood glucose every hour through two hours and then measure every two hours until reaching the target range when the BG level falls out of the target range or if algorithm moves.

Treating hypoglycemia
- Turn off the insulin infusion
- Administer 25 ml of dextrose 25% bollus, and recheck BG after 30 mins and administer 25 ml of dextrose 25% if BG still = 70 ml/dl
- Stop infusion and recheck each hour if BG ? 70 but = 110 mg/dl, or if BG ? 110but = 150 mg/dl
- Recheck blood glucose every 2 hour and restart the algorithm 0

Notify the physician:
- For any change in the BG level more than 100 mg/dl between two consecutive measurements
- If BG level = 300 mg/dl
- For unresponsive hypoglycemia that doesn't resolve after 20 mins of 25% intravenous dextrose

Failure of algorithm 4, consult the endocrinologist

Box 1: Nurse led insulin protocol that was adapted from Khalilah et al. [24].

For the control group (group A) who were managed by the routine management of the ICUs; the BG level was measured and documented in the part II of the tool. While, for the intervention group (group B), the doses of insulin were adjusted and the blood glucose values was documented in the part II of the tool according to the nurse led insulin

protocol algorithm (Box 2). The BG was monitored by a calibrated point of care device (ACCU check active; Germany).

BG mg/dl	Algorithm 0	Algorithm 1	Algorithm 2	Algorithm 3	Algorithm 4
110-149	0-0.5 (ml/h)	0.5	1	1.5	2
150- 179	0.5 (ml/h)	1	2	3	4
180-209	1 (ml/h)	2	3	4	5
210-239	1.5 (ml/h)	3	4	5	6
240-269	2 (ml/h)	4	5	6	7
270-299	2.5 (ml/h)	5	6	7	8
300-329	3 (ml/h)	6	7	8	9
330-359	4 (ml/h)	6	7	9	11
>360	5 (ml/h)	8	12	14	16

Box 2: Nurse led insulin protocols' algorithm [21,24,25].

Administrative and ethical issues

The study protocol was approved by the research and ethics committee in the Faculty of Nursing, Alexandria University. A written informed consent was obtained from each conscious patient or from the responsible person after explanation of the aim of the study. Anonymity, Privacy of the patient; confidentiality of the collected data, and the right to refuse participation in the study were assured.

Statistical analysis

The SPSS V 21.0 was used for the analysis of the data. Reliability of the tool was determined by Cronbach alpha. Frequency tables and cross tabulations were used to illustrate the results of categorical data and tested by the Pearson Chi Square Test and Fisher's Exact Test. Quantitative data were summarized by the arithmetic mean and standard deviation. Comparison of means was done by student t-test.

Results

Table 1 demonstrates the demographical and clinical characteristics of both groups. It shows that there are no significant difference between the control and the intervention groups regarding the age, sex or BMI (p. value=0.271, 0.211, 0.871). It also indicates that there are no significant relationship regarding the history of diabetes mellitus, or past surgical history between the both groups. Regarding the reason of admission the table shows that neurological related causes were the highest reason of admission followed by cardiac related causes, respiratory, and trauma related causes. The table also indicates that there are no significant differences between the control and the study groups regarding the reason of admission (p value=0.448).

Characteristics	Control group	Intervention group	p. value
Age (mean SD)	47.0 ± 10.78	49.9 ± 9.36	0.271
Sex, female (N)	17	21	0.211
BMI (mean SD)	23.55 ± 5.26	23.76 ± 4.80	0.871
History of DM (N)	17	15	0.861
Surgical history, present (N)	8	9	0.386
Reason of admission			
Neurological	11	12	
Cardiac	6	4	
Respiratory	5	4	0.448
Trauma	4	5	
others	4	5	
Glasgow coma scale (>8)	21	22	0.726
Drugs			
Sedatives	14	16	0.398
Analgesics	14	13	0.5
Vasopressors	19	18	0.5
steroids	15	13	0.378
Nutrition, EN (N)	26	27	0.611

Table 1: Demographical and clinical characteristics of the control and intervention groups.

The same table also indicates there are no significant differences between the control and the study groups regarding the Glasgow coma score, common infused drugs that patient has been received during the period of the study, or the type of nutrition. The table totally depicts that the control and the study groups were matched.

Table 2 and Figure 1 demonstrate the comparison between the control and intervention group according to the mean of blood glucose level during the period of the study. It shows that there is no significant difference between the control and intervention groups at the baseline of the blood glucose level (324.7 ± 90.4 versus 317.53 ± 112.7, P, value=0.758). The BG level had gradually decreased among the study group until a highly significant difference between the control and the study group has appeared at the end of the first eighth hours of intervention (306.1 ± 103.8 and 202.73 ± 59.98, P. value=0.007).

Measurements times	Control group (n=30)	Intervention group (n=30)	t- test	p-value
	Mean ± SD	Mean ± SD		
Baseline measurement	324.7 ± 90.4	317.53 ± 112.7	25%	0.785
After 1 hour	342.5 ± 105.8	301.39 ± 90.20	1.599	0.115
After 8 hours	307.3 ± 80.3	251.7 ± 73.5	2.322	0.031
After 16 hours (mean ± SD)	272.6 ± 82.1	176.1 ± 41.1	3.417	0.001
After 24 hours (mean ± SD)	293.4 ± 81.3	175.3 ± 57.2	2.556	0.027

2nd day	268.1 ± 98.7	166.± 59.0	4.981	0
3rd day	303.9 ± 98.3	151.7 ± 56.9	5.677	0
4th day	251.3 ± 64.6	169.7 ± 65.9	2.116	0.008
5th day	291.6 ± 64.1	167.5 ± 54.6	4.874	0.003
Total (mean ± SD)	285.0 ± 81.4	163.9 ± 40.5	//////////	0.002

Table 2: Comparison of mean blood glucose between the control and the study groups during the period of the study.

In the second eight hours of the nurse led insulin protocol implementation; the BG levels were measured each two hours; it shows that the mean among the still decreasing and highly significant differences were observed between the control and s (272.6 ± 82.1 versus 176.1 ± 41.1; P value=0.001). Then, in the third eight hours of the nurse led insulin protocol implementation; BG levels were measured every four hours; the same table also demonstrates a significant differences between the control. Totally at the end of the first 24 hours; a significant difference was found between the both groups (293.4 ± 81.3 versus 208.3 ± 57.2, p-value=0.027).

Table 4 also indicates that the mean BG level in the second and third day has obviously decreased in all measurement times among the intervention group. The table shows a highly significant differences between the control and intervention group (268.1 ± 98.7 and 303.9 ± 98.7 versus 166.9 ± 59.0 and 151.7 ± 56.9; P. value=0.000 and 0.001 respectively).

In the same line, the table shows that BG among the study group still lower than those of control group during the fourth and fifth day of the nurse led insulin intervention. A highly significant differences were found between the control and study groups. Figure 1 also demonstrates the trends of significant differences between the control group and study group throughout five day of study.

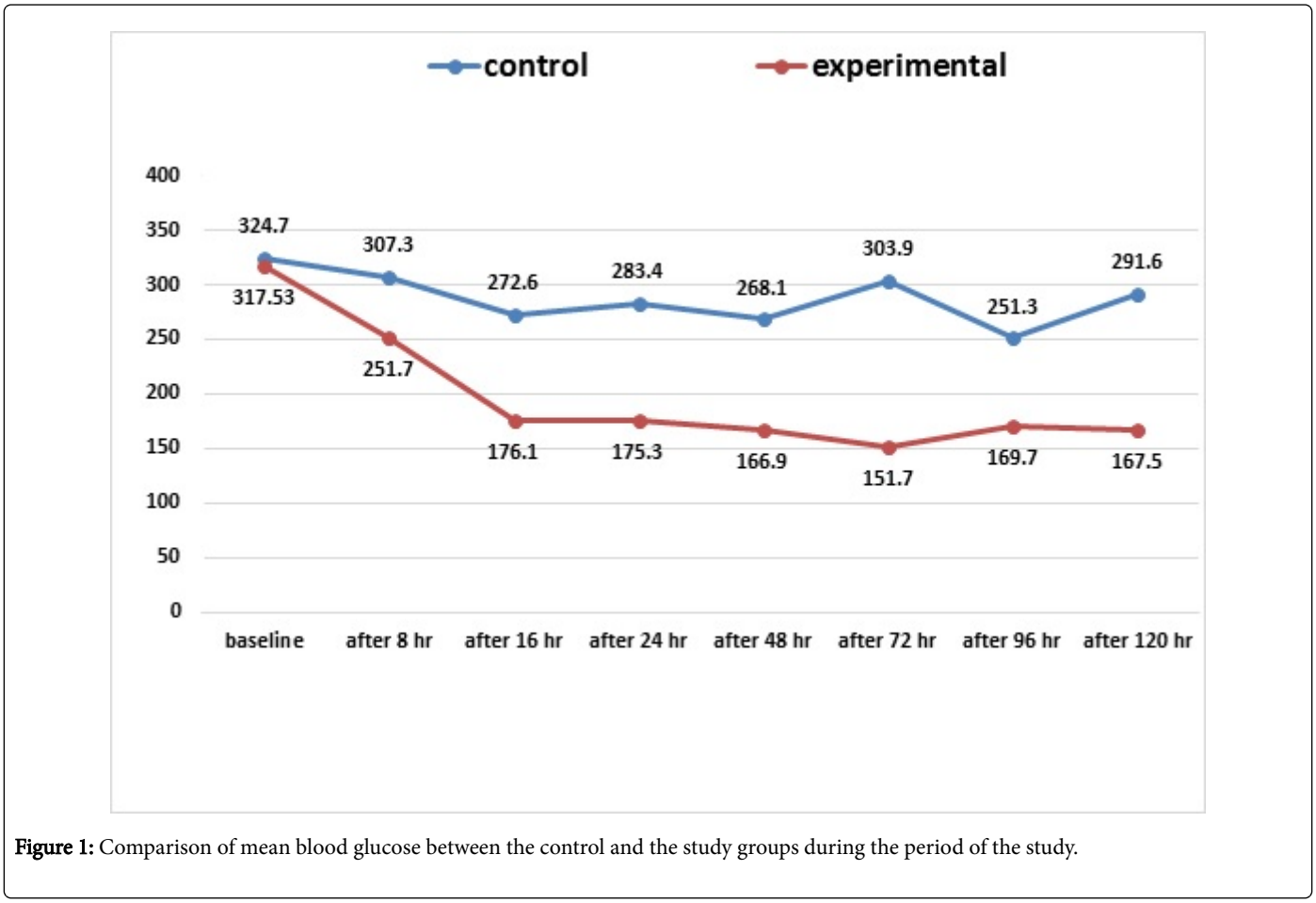

Figure 1: Comparison of mean blood glucose between the control and the study groups during the period of the study.

Discussion

The efficacy of the nurse led insulin protocol in the present study has been evaluated throughout five days after admission. This period has to be considered for achieving an intended effect of the IIT in several landmark studies. The baseline measurements of the BG at the time of admission in the present study were high among both groups of the study, it can be seen that insignificant difference between them were found. In the first eight hours of the nurse led insulin protocol implementation, hourly monitoring revealed decreasing in the mean BG level among the lower than the control group. This may be attributed to the early initiation of insulin infusion and appropriate dose titration in relation to the nurse led insulin algorithm, which means that the titrating algorithms was an effective.

In the present study; although a significant difference between the control and intervention group were found at the end of first six hours of the nurse led insulin protocol implementation, the mean BG level of both groups still at the hyperglycemia level. The level of BG among the

intervention group has required sixteen hours of the nurse led insulin protocol to slide down into the permissive hyperglycemia level. The level which is an acceptable level for critically ill patients according to the recommendation of ADA and the sepsis survival campaign [26,27].

In consistent with the present result, several studies of implementation of a safe and effective insulin infusion protocol in the ICUs also reported that the BG level at admission was high and the protocol target need more time to be achieved [24,28,29]. Berghe et al. reported that the BG reached the glucose target in the beginning of the second day of treatment by the IIT [30].

In the same line Goldberg et al. [28] evidenced that BG level required about twelve hours to be lower than 180 mg/dl. Furthermore, Zochios et al. [31] in their retrospective study of hyperglycemia management practices found that none of the patients met the standard of 8.0–10.0 mmol/L (144-180 mg/dl) for the audit period of 48 hours after admission.

It was documented that several factors challenge achieving strict glycemic control during ICU stay, this may include severity of illness and degree of insulin resistance that may fluctuate, nutritional delivery may change, and interventions such as administration of corticosteroids may produce frequent changes in insulin needs [32]. In the current study; the high BG level at admission among the both groups may be the cause of prolonged time needed for achieving permissive hyperglycemia level (150-180 mg/dl), in addition to fear of the staff from occurrence of hypoglycemia and lack of physicians' support for the tight insulin protocol. Therefore, only small percent of the intervention group in this study reached to the protocol target (110-149 mg/dl).

In the opposite side the results in the present study are inconsistent with Leelarathna et al. [33] in their randomized study conducted to investigate the feasibility of fully automated closed-loop glucose control using continuous subcutaneous glucose measurements in critical illness. They reported that closed loop therapy achieved BG target within the first 4-8 hours of intervention.

The critical care nurses play a pivotal role in monitoring and management of the critically ill patients. They are part of the multidisciplinary team, who should be decision maker, good observer and should report any abnormalities and evaluate the outcomes of the related nursing interventions to improve the patients' quality of life, decrease length of stay, improve the patients' outcomes, and decrease the resources utilization.

In clinical field, nurses led insulin protocol of insulin has several potential advantages; continuous availability of the nurses at patients' bedside, the nurses are more familiar than other health care providers with patients' characteristics and responses. However a multidisciplinary team and other medical staff must be involved, it still titled as a nurse-led protocol. Moreover, nurses have experience and receive training in titrating doses of infused medications, and able than other providers to respond proactively to a patient's rapidly changing needs. This approach increases nurses' autonomy; a concept that has been associated with increasing their perceptions of improved quality of care and job satisfaction.

Conclusion and Recommendation

Nurses' led insulin protocol has strongly and consistently linked with better glycemic control and improved clinical outcomes in various groups of patients. Implementation of nurse led protocols increases nurses' autonomy; a concept that has been associated with increasing their perceptions of improved quality of care and job satisfaction.

Form the findings of the current study, it can be concluded that, the hyperglycemic mechanically ventilated patients who were managed by the nurse led insulin protocol experienced lower mean blood glucose level than those who were managed by routine management of the ICUs. Thus, it recommended to:

- Apply the nurse led insulin protocol to achieve a normal blood glucose level for critically ill patients.
- Develop in-service education and training programs to increase critical care nurse's awareness regarding nurse led insulin protocol for glycemic control.
- Construct multi-disciplinary team to implement nurse led insulin protocol.
- Replicate this study on a larger sample size, in multicenter and for longer duration for generalization of the results.

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