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Assessment of Hyperglycemia in response to dietary management and severity of illness in ICU patients

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ABSTRACT

Hyperglycemia among hospitalized critically ill patients has been shown to be an independent predictor of poor outcomes. The aim was to assess the level of hyperglycemia with different dietary regimens of ICU patients (oral, and enteral feeding) and to correlate levels of blood glucose with the severity of the diseases. A prospective cohort study was conducted at ICU of King Fahad Medical City in Riyadh, Saudi Arabia, during the period between April and August 2017. Thirty-four patients from both sexes, 27 - 79 years were randomly selected. The first 24 hours' blood glucose test was taken at the time of admission then twice/month and for a maximum of three months. The last blood glucose levels were recorded at the time when referred to the ward or at the time of discharge. The severity of illness was assessed by APACHE II score which was recorded during the first 24 hours after admission and at the time when referred to the ward or the discharge. A total of 34 subjects, 67.6% males and 32.4% females were enrolled. Their age of the subjects was 62.1±13.3 years. The mean body mass index was 27.0±5.2 kg/m2 and that of the females was significantly higher than that of the males (30.9 versus 25.1 kg/m2). The means blood glucose levels were insignificantly different between orally-fed and tube-fed patients (9.7±3.7 vs 9.5±3.2 mmol/l, respectively). Regarding the severity of the diseases, there is a positive correlation between blood glucose level and the severity of the disease assessed by APACHE II score ($r=0.543$, $p<0.5$). The mode of feeding did not affect the glycemic levels in critically ill patients and the simple blood glucose level might be used as an indicator of severity of the disease.

Keywords: Hyperglycemia, enteral feeding, ICU patients, Disease severity.

INTRODUCTION

Hyperglycemia among hospitalized critically ill patients has been shown to be an independent predictor of poorer outcomes. Appropriate treatment of hyperglycemia has been associated with reduced mortality and morbidity among these patients (Brady, 2013). Critically ill patients manifest a significant metabolic stress response. This metabolic response to stress is complex and is mediated through interaction between the neuro-endocrine axis and circulating cytokines, which may be the main cause of hyperglycemia in non-diabetic intensive care unit (ICU) patients. Hyperglycemia may be a sign of infection or inflammation due to the effect of increased hormones and cytokines levels (Moghissi, 2010).

Egi *et al.,* (2011) reported that approximately 90% of patients treated in an ICU developing hyperglycemia. Hyperglycemia can also result from the provision of excessive calories from parenteral and enteral nutrition, as well as from dextrose infusion that are commonly used for fluid resuscitation and for the delivery of medication (Egi *et al.,* 2006).

Critically ill patients are at particular risk of malnutrition, which occurs in up to 40% of the cases. The metabolic changes that occur in response to stress lead to an increase in protein catabolism, resulting in a significant loss of lean body mass, which in turn results in a higher incidence of complications, especially infectious ones, in an increase in wound dehiscence and in unfavorable outcomes (Osooli *et al.,* 2019). The main purpose of nutritional support is to prevent malnutrition and its associated complications, by modulating the stress response of the patients. This objective will be achieved by providing the appropriate doses of macro- and micro-nutrients to meet the calculated or measured needs, avoiding complications associated with nutritional support, reducing nitrogen deficits and modulating the inflammatory response through the use of different substrates (Seron-Arbeloa *et al.,* 2013).

It is important to assess the level of hyperglycemia in response to dietary management and severity of illness in ICU patients, since there was no published data from ICU centers in Riyadh city. The results and recommendation of the study may help the IUC centers. This study correlates the relationship between hyperglycemia, dietary management, and severity of the illness in ICU patients in king Fahd Medical City, Riyadh.

MATERIALS AND METHODS

Settings of the study:

The perspective cohort study was conducted at ICU of King Fahad Medical City in Riyadh administrated by the Ministry of Health. in accordance with an experimental protocol approved by the Institutional Review Board from King Fahad Medical City under reference number: H-01-R-012.

Study subjects

The subjects were non- diabetic patients attending the ICU for different medical conditions. Thirty-four critically ill patients from both sexes (males and females) age 27 - 79 years were selected randomly. All cases stayed in ICU for at least 24 hours with hemodynamic stability were included. The exclusion criteria were patient with age more than 79 years or less than 18 years and pregnant ladies.

Data Collections

The demographic data including age and sex were recorded. Details of all foods and nutritional formulas introduced to the patients were recorded to determine the dietary intake from different nutrients. Anthropometric measurements and clinical assessment including height, weight, body mass index was recorded from the patients file.

The blood glucose was recorded from the patients file record at the time of admission. The first 24 hours blood glucose test from the time of admission then twice/month and for maximum of three month. Second was recorded at the time when referred to ward or at the time of discharge if it is less than three months.

The severity of illness was assessed by Acute Physiology and Chronic Health Evaluation (APACHE II) (Knaus *et al.,* 1985). The APACHE II score was recorded during the first 24 hours from admission and second was recorded at the time when referred to ward or at the time of discharge.

Feeding pattern used in ICU patients in this study

Oral menu used in ICU patients in this study planned by a clinical dieticians who were well trained and had been registered (professional registration) in the Saudi

Health Commission for Health Specialties. Patient after seen by the doctor referred to the dietician who first assessed the nutritional status and see the diagnosis of the disease or accidents.

The dieticians then plan the dietary meals and consult the medical teams to decide the route of feeding (Oral feeding or tube feeding) and when to start feeding the patient(s).

The common enteral formulae used in ICU patients in this study were standard formulae or hyperglycemia-specific formulae such as Glucerna, Resource diabetic, or other disease specific formulae such as Nepro. The dietary components of these formulae were presented in table 1.

Statistical Analysis:

Statistical package for Social Sciences (SPSS) version 20 was used to carry out data editing, coding, and analysis. The descriptive statistics was used to analyze data collection. Results ware expressed as mean +/ - SD. Statistical significance made between different variable by student's t test, to compare between study variables. Person correlation coefficient was used to determine relationships between hyperglycemia, dietary management, and severity of illness in ICU.

RESULTS

Basal characteristics of study subjects were presented in table 2. the total number involved in this study was 34 subjects. 23 males representing 67.6% of the total subjects, whereas there were 11 females constituting 32.4% of the total subjects.

The mean of daily total energy, protein, carbohydrate and fat (±SD) of the subjects were 1597.4 (± 209) kcal, 77.1 (± 15.9) grams, 195 (± 52.4) grams and 58.7 (± 16.9) grams respectively. The mean intake of fiber during the first visit was 19.7 (± 7.2) gram, and the mean water intake of the total subjects was 1341 (± 360.8) ml daily. Macronutrients intake of the subjects fed orally vs those on enteral feeding during the first visit was showed in table 3. The subjects fed on oral feeding took more protein and carbohydrate than the subjects who were fed by tube feeding and the difference were highly significantly (P<0.001) for both proteins and carbohydrate. The subjects who were fed on oral feeding took less fat than the subjects who fed by tube feeding (47.4 grams versus 68.7 grams) and the difference was highly significant (P<0.001). Longitudinal analysis of the daily mean energy and macronutrient intake of all subjects whether oral or tube feeding, the mean (± SD) energy intake during the study period was presented in table 4.

Table 1: The dietary component of the formulas used in this study.

NUTRITION INFORMATION	GLUCERNA* (1000 ML)	# PEPTAMEN (1000 ML)	FIBER # SOURSE (100 ML)	FORTISIP** (100 ML)	RESOURSE DM # (100 ML)	NEPRO* (1000 ML)
ENERGY	1000kcal	1000kcal	124kcal	150kcal	101kcal	1800KCAL
PROTEIN	41.8g	40g	5.4g	6.0g	4.5g	81.0G
CARBOHYDRATE	95.6g	130g	15.6g	18.4g	9.8g	166.8G
FAT	54.4g	39g	4.1g	5.8g	4.4g	96.0G
FIBER	14.4g	0g	1.5g	----	1.9g	15.6G
WATER	853G/ML/CC	ACCORDING TO DIETITIAN-	81.2ML/CC	76.5ML/CC	85ML/CC	725G/ML/CC

Table 2: Basal characteristics of study subjects.

Indicator	Males Mean ± SD	Females Mean ± SD	P-value
Age (year)	61.7±14.8	62.8±9.9	0.964
Height (cm)	164.3 ± 5.1	153.7 ± 7.6	**0.01**
Weight (kg)	67.7 ± 11.9	73.9 ± 12.5	0.17
BMI (kg/m²)	25.1 ± 4.2	30.9 ± 4.9	0.04

Table 3: Daily macronutrients and water intake of the subjects during the first visit according to the type of feeding

Nutrients (No of subjects)	Oral Feeding (16) Mean (±SD)	Tube Feeding (18) Mean (±SD)	P-value
Total energy (Kcal)	1650 ± 159	1550 ± 240	0.16
Protein (grams)	88.5 ± 8.7	66.9 ± 17.0	0.001
Carbohydrate (grams)	227.7 ± 32.1	168.6 ±53.3	0.001
Fat (grams)	47.4 ± 7.0	68.7 ± 16.0	0.0001
Fiber (grams)	24.1 ± 3.3	15.8 ± 7.6	0.0001
Water (ml)	1670 ± 92.0	1048 ± 229	0.001

Table 4: The daily mean energy and macronutrient intake of the subjects during the study

Visit	Mean of energy intake Kcal/day	Protein gram (%from total calorie)	Carbohydrate gram (%from total calorie)	Fat gram (%from total calorie)
First visit (n=34)	1597.4± 209	77.1 ± 15.0 (19.3 % ± 3.3)	194.9 ± 52.3 (48.1% ± 8.6) *	58.6± 16.9* (32.6 % ± 10.0)**
Second visit (n=34)	1620.5±263	83.2 ± 15.8 (20.5% ± 2.5)	195.6 ± 50.5 (48.1% ± 8.9)	58.8 ± 21.8 (31.4 % ± 9.7)
Third visit (n=8)	1587.7±396	70.9 ± 19.6 (18.1% ± 3.7)	164.4 ± 53.7 (42.6 % ± 9.4)	73.4 ± 36.1 (39.3 % ± 10.1)
Fourth visit (n=7)	1600.2±426	71.7 ± 20.1 (18.1% ± 3.8)	159 .4 ± 35.5 (41.1 %± 9.1)	77.7 ± 36.7 (40.8% ± 8.9)
Fifth visit (n=6)	1576.6±387	67.2 ± 17.1 (17.0 % ± 1.3)	154.9 ± 29.1 (40.3% ± 7.9)	77.0 ± 34.6 (42.7% ±9.5)
Sixth visit (n=3)	1765±562*	77.0 ± 33.8 (17.1 % ± 1.9)	159.6 ± 20.6 (38.1% ± 10.9)*	92.9 ± 46. 4 (44.8% ± 10.5)**

***=p-value <0.05 and **= p-value <0.01 compared visit one**

The means blood glucose levels were insignificantly different between orally-fed and tube-fed patients as evident in table 5 (all p trend >0.05). Blood glucose levels and disease severity with their correlations during the study were shown in table 6. It was evident that the glucose level is positively correlated with disease severity. Some visits with no significant correlation were due to low number of subjects.

DISCUSSION

The current study proves that the glycemic level was not related to the pattern of feeding and the glycemic level is significantly correlated with the disease severity. There is a wide array of different disease-adapted enteral formulas that may be beneficial in certain clinical conditions however use of standard formula or oral feeding gave the similar results. To minimize the risks, development of procedural protocols with regular quality controls and audits, and monitoring by dedicated dieticians are recommended (Kolaček S, 2013). Using enteral ready formulas let the dietician surer about the amount of exact nutrients used compared to those use filtrated mixed food (Metheny, *et al.,* 2009).

The mean energy intake of the subjects at the first visits was 1597.4 ± 209 kcal/day, which increased to 1620 kcal in the second visit. In a prospective randomized pilot clinical trial conducted in an adult general ICU, concluded that, providing near target energy requirements was achievable and the intake of a higher percentage of prescribed dietary energy goal via enteral route was associated with improved 60-day survival (Mehta *et al.,* 2012).

Table 5: The means blood glucose levels comparison between orally-fed and tube-fed patients

Visits (No of subjects)	Oral Feeding	Tube Feeding	P-value
	Mean (±SD)	Mean (±SD)	
First visit (n=34)	9.1± 2.3	9.2±3.6	0.896
Second visit (n=34)	8.4 ±2.7	8.9 ± 1.9	0.743
Third visit (n=8)	8.7± 3.2	8.2 ±3.3	0.651
Fourth visit (n=7)	6.7 ± 1.7	7.1 ± 1.6	0.213
Fifth visit (n=6)	9.1 ± 3.3	8.7 ± 3.6	0.541
Sixth visit (n=3)	9.2 ± 3.2	8.9± 2.9	0.001
Those at discharged for all subjects (n=34)	9.7±3.7	9.5±3.2	0.768
Those discharged after second visits (3th,4 th,5 th and 6 th) visits (n=8)	8.7±2.3	8.9±3.1	0.743

Table 6: The mean blood glucose levels, illness severity of the subjects and their correlations during the study.

Visit	Mean of blood glucose mmol/liter	Mean illness severity of the subjects	Pearson correlation coefficient
First visit (n=34)	9.99±2.79	20.1±7.1	0.543*
Second visit (n=34)	9.63±3.36	15.3±8.9	0.347*
Third visit (n=8)	8.36±1.36	11.0±6.6	0.435
Fourth visit (n=7)	6.67±1.00*	13.0±5.6	0.456
Fifth visit (n=6)	8.73±2.64	13.0±5.2*	0.342
Sixth visit (n=3)	8.00±2.40	21.0±3.6	0.432
Those at discharged for all subjects (n=34)	8.9±3.3	16.2±7.5	0.563*
Those discharged after second visits (3th,4 th,5 th and 6 th) visits (n=8)	7.4±1.9*	15.7±5.5	0.432

***=p-value <0.05**

The mean energy intake of the subjects at the first visits was 1597.4 ± 209 kcal/day, which increased to 1620 kcal in the second visit. In a prospective randomized pilot clinical trial conducted in an adult general ICU, concluded that, providing near target energy requirements was achievable and the intake of a higher percentage of prescribed dietary energy goal via enteral route was associated with improved 60-day survival (Mehta *et al.,* 2012).

In the first visit the mean daily carbohydrate intake was 194.9 grams which constitutes 48.1% from the total calorie and the mean fat intake was 58.6 grams which constitutes 32.6% from the daily total calorie. In the sixth visit the result showed that the mean daily carbohydrate intake was 159.6 grams which constitutes 38.1% from the total calorie and the mean fat intake was 92.9 grams which constitutes 44.8%% from the daily total calorie. These findings were in line with those of Bolder et al (2009).

Findings in this study show that the decrease of total calorie intake in the third visit could be due to different reasons. Several factors limit adequate nutritional intake in ICU patients given enteral feedings. O'Leary-Kelley (2005) reported the common causes of inadequate nutritional intake in critically ill patients include episodes of diarrhea, emesis, large residual volumes, feeding tube replacements, and interruptions. Procedural interruptions alone accounted for 45% of the total variance. Heidegger *et al.,* (2013) showed that individually optimized energy supplementation with supplemental parenteral nutrition should be considered as a strategy to improve clinical outcome in ICU patients for whom enteral nutrition is insufficient.

In this study the total calorie intake was significantly higher among patients taking oral feeding compared to patients with NGT feeding. This agrees with what reported by Seron-Arbeloa *et al.,* (2013). They reported that the total calorie intake was higher among patients taking oral feeding compared to patients with tube feeding

In this study the fat constituent of the total calorie in the sixth visit was higher (44.8%), whereas the carbohydrate constitutes only 38.1% from the daily total calorie (not standard formula). This could be explained by the fact that most of the patients admitted to ICU during the sixth visit were having respiratory problems. Pulmonary disease formulas usually were high in fat and low in carbohydrate. Enteral nutrition formulas enriched with eicosapentaenoic acid and gamma-linolenic acid may modulate inflammatory processes and improve outcomes in mechanically-ventilated patients with respiratory failure (Cohen *et al.,* 2013).

In the ICU, the threshold to start treatment is a blood glucose concentrations of ≥ 180 mg/dl. Intravenous insulin is the treatment of choice in critically ill patients because of its rapid onset and offset of action. Once insulin is started, the blood glucose concentrations should be maintained between 140 and 180 mg/dl, a blood glucose level of <110 mg/dl or >180 mg/dl are no longer recommended (Singer *et al.,* 2019). In this study the mean of blood glucose level in the first visit for those taking food through oral feeding was 9.1± 2.3 mmol/l while those taking nutrients through nasogastric tube was 9.2±3.6 mmol/l and the difference was not significant, which means that the route of feeding is not the cause of high blood glucose levels. One may ask why a critically ill patients, who were not eating well for a number of hours or days having a high blood glucose level. There were two reasons the critical phase following the accidents, burns or sepsis cause mobilizing of nutrients and increase gluconeogenesis and glycogenolysis (stress hyperglycemia).

One of the main causes of hyperglycemia in critically ill patients is the release of counterregulatory stress hormones and proinflammatory cytokines, in addition to increased production of glucose along with its decreased utilization. In the past, stress hyperglycemia was thought to be an evolutionary protective, natural adaptive response of the body to current threat, which allows increased entry of glucose into the cells of non-insulin-tissues, thus improving chances for survival. At present, however, this state of insulin resistance, glucose intolerance and hyperglycemia is called "stress diabetes" or "diabetes of injury (Yan *et al.,* 2013).

Our data assessing the relationship between the level of hyperglycemia and severity of illness in ICU patients had showed that, hyperglycemia may be a sign of severity of the illness of ICU patients. This may be due to the effect of increased hormones and cytokines levels that lead to increase blood glucose through different mechanisms (Holzinger, 2013).

Optimal glycemic control remains a challenge among hospitalized patients. Insulin is the most appropriate agent for management of hyperglycemia for the majority of hospitalized patients rather than reduction of dietary carbohydrates. The frequent and effective glucose monitoring is critical for avoiding wide deviations from acceptable glucose levels (Moghissi, 2010).

CONCLUSION

The mode of feeding did not affect the glycemic levels in critically ill patients and the simple blood glucose level might be used as an indicator of severity of the disease. Furthermore, use of exogenous insulin is much better than reduction of dietary carbohydrates.

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Competing interests
Authors have declared that no competing interests exist.

REFERENCES

Bolder U, Ebener C, Hauner H, Jauch KW, Kreymann G, Ockenga J, Traeger K (2009) Working group for developing the guidelines for parenteral nutrition of The German Association for Nutritional Medicine. Carbohydrates - guidelines on parenteral nutrition, chapter 5. Ger Med Sci 7.

Brady V (2013) Management of hyperglycemia in the intensive care unit: when glucose reaches critical levels. *Crit Care NursClin North Am*., 25:7-13.

Cohen DA, Byham-Gray L, Denmark RM (2013) Impact of two pulmonary enteral formulations on nutritional indices and outcomes. *J Hum Nutr Diet.*, 26:286-93.

Egi M, Bellomo R, Stachowski E, French CJ and Hart G (2006) Variability of Blood Glucose Concentration and Short-term Mortality in Critically Ill Patients. *Anesthesiology*, 105: 244-252.

Egi M, Finfer S and Bellomo R (2011) Glycemic control in the ICU. Chest 140: 212-220.

Heidegger CP, Berger MM, Graf S, Zingg W, Darmon P, Costanza MC, Thibault R, Pichard C (2013) Optimisation of energy provision with supplemental parenteral nutrition in critically ill patients: a randomised controlled clinical trial. *Lancet.*, 381:385-393.

Holzinger U (2013) Glucose control in the critically ill. Innovations and contemporary strategies. *Med Klin Intensivmed Notfmed*,108:422-428.

Knaus WA, Draper EA, Wagner DP, Zimmerman JE (1985) APACHE II: a severity of disease classification system". Critical Care Medicine 13: 818–829.

Kolaček S (2013) Enteral nutrition. *World Rev Nutr Diet* 108:86-90.

Mehta NM, Bechard LJ, Cahill N, Wang M, Day A, Duggan CP, Heyland DK (2012) Nutritional practices and their relationship to clinical outcomes in critically ill children--an international multicenter cohort study. *Crit Care Med* 40:2204-11.

Metheny, Charles Mueller, Sandra Robbins & Jacqueline Wessel (2009) Enteral Nutrition Practice Recommendations. *Journal of Parenteral and Enteral.*, 33: 122-167.

Moghissi ES (2010) Reexamining the evidence for inpatient glucose control: new recommendations for glycemic targets. *Am J Health Syst Pharm*, 67:S3-8,.

O'Leary-Kelley CM, Puntillo KA, Barr J, Stotts N, Douglas MK (2005) Nutritional adequacy in patients receiving mechanical ventilation who are fed enterally. *Am J Crit Care*, 14:222-31.

Osooli F, Abbas S, Farsaei S and Adibi P (2019) Identifying Critically Ill Patients at Risk of Malnutrition and Underfeeding: A Prospective Study at an Academic Hospital. *Advanced pharmaceutical bulletin,* 9(2): 314–320.

Seron-Arbeloa C, Zamora-Elson M, Labarta-Monzon L, & Mallor-Bonet T (2013) Enteral Nutrition in Critical Care. J Clin Med Res 5: 1–11.

Singer P, Blaser Ab, Berger MM, Alhazzani W, Calder PC, Casaer MP, Hiesmayr M, Mayer K, Carlos Montejo J, Pichard C, Preiser J, van Zanten R, Oczkowski S, Szczeklik W, Bischoff SC (2019) ESPEN guideline on clinical nutrition in the intensive care unit. *Clinical Nutrition* 38:48-79.

Yan CL, Huang YB, Chen CY, Huang GS, Yeh MK, Liaw WJ (2013) Hyperglycemia is associated with poor outcomes in surgical critically ill patients receiving parenteral nutrition. *Acta Anaesthesiol Taiwan*. 51:67-72.