THE RELATIONSHIP BETWEEN HYPERGLYCEMIA STATUS AND HIGH GASTRIC RESIDUAL VOLUME STATUS IN ADULT ICU PATIENTS

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Abstract—Introduction: Hyperglycemia commonly occurs in critically ill patients due to metabolic stress. Hyperglycemia can cause gastric motility disturbance in which can cause high gastric residual volume (GRV). The objective of this study is to determine the relationship between hyperglycemia and high GRV status in ICU patients.

Methods: This study used cross sectional method with consecutive sampling of 96 adult ICU patients. Blood glucose level were measured every 12 hours and GRV every 4 hours on first and second day admission to ICU. Data were analyzed with Statistical Package for Social Science Program (SPSS) version 20.0. The relationship between hyperglycemia status and high GRV status were analyzed using Chi-Square test.

Results: Hyperglycemia status was found in 45.8% subjects on day 1 and 35.4% on day 2. High GRV status was found in 28.1% on day 1 and 25% on day 2. There was no significant relationship between hyperglycemia and high GRV status on day 1 and 2 (p=0.34 and 0.81). However, in 12 subjects, we found high GRV occurred 19.67 ± 11.06 hours after the onset of hyperglycemia.

Conclusion: There was no significant relationship between hyperglycemia status and high GRV status, but high GRV could be found later after hyperglycemia.

Keywords: critically ill patients, hyperglycemia, gastric residual volume

INTRODUCTION

Hyperglycemia commonly occurs in critically ill patients due to metabolic stress, even though without history of diabetes.¹³ The prevalence of hyperglycemia varies in many researches. Van den Berghe et al⁴ found 12% of critically ill patients had blood glucose level >200 mg/dL. Another study by Cely et al⁵ found 38% of critically ill patients had blood glucose level >150 mg/dL and 23% of them had >200 mg/dL. Unfortunately, data about prevalence of hyperglycemia in critically ill patients has not been found in Indonesia yet.

Based on the Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation (NICE-SUGAR), hyperglycemia in critically ill is defined by blood glucose level >180 mg/dL⁶ It occurs due to insulin resistance and the increase of gluconeogenesis in responds to inflammation.¹³ It can also occur due to excessive intake and corticosteroids therapy.¹⁷

Hyperglycemia may results in gastric motility disturbance which alter gastric emptying and, therefore, can cause high gastric residual volume.⁸⁹ A study by Nguyen et al¹⁰ shows high gastric residual volume occurred more often in patients who had hyperglycemia. The cut off points of high gastric residual volume varies from >150 mL to >500 mL.¹¹–¹³ In Intensive Care Unit of Cipto Mangunkusumo Hospital, the cut off point used is >125 mL every 4 hours.

Prevalence of high gastric residual volume varies from 32–60%.¹³,¹⁴ A study by Junizar¹⁵ in Cipto Mangunkusumo Hospital ICU found 23.3% of critically ill patients had high gastric residual volume. This condition can hinder adequate enteral feeding¹⁴ and increase the risk of aspiration¹⁶ which results in increase of mortality.¹⁷,¹⁸ Other causes of high gastric residual volume are low perfusion,¹⁹ sympathetic response during metabolic stress,²⁰ low potassium level,⁹ opioids and cathecolamine therapies.¹⁴,²¹

There are only few studies regarding the relationship between hyperglycemia in critically ill patients and high gastric residual volume. However, there is still no research data regarding this issue in Indonesia. Therefore, this study was conducted in ICU of Cipto Mangunkusumo General Hospital, Jakarta, Indonesia. The results of this study was expected to be able to estimate the percentage of hyperglycemia and high gastric residual volume for
additional knowledge in nutrition therapy for critically ill patients, especially in Indonesia.

**METHODS**

The study was done in May to August 2014 in Cipto Mangunkusumo General Hospital, Jakarta, Indonesia, and had been approved by the Ethics Committee of the Faculty of Medicine, University of Indonesia. The inclusion criteria were male and female, age 18–59 years old, had nasogastric or orogastric enteral tube applied, and consented by their family or relatives to participate in this study. Any patient who had surgical procedure involving removal of pyloric sphincter was excluded. Data were collected within the first and second 24 hours of admission in ICU. Subjects who had earlier enteral tubes removal, left ICU (move to ward) or passed away before data collection was completed were dropped out from this study. The data was collected in the first and second 24 hours of admission in ICU to avoid large number of drop outs, loss to follow up, and too much data variation because the staying time differs greatly in this ICU.

The sample size was determined with the formula below and subject was recruited consecutively. According to formula below, minimum number of subject should be recruited was 96 patients.

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n = \frac{Z_{\alpha}^2 \times P \times Q}{d^2}
\]

- \(n\) = number of subject
- \(Z_{\alpha}\) = cut off point for statistical significance = 1.96, for \(\alpha = 0.05\)
- \(P\) = percentage of high gastric residual volume in critically ill patient with hyperglycemia. \(P\) was assumed to be 50\% = 0.5
- \(Q\) = 1 - \(P\)
- \(d\) = acceptable drop out rate in clinical research = 10\%

The data collected were age, gender, weight, BMI, nutritional status, calorie intake, diagnosis, serum potassium level, MAP status, use of opioids and catecholamines from ICU medical charts. Blood glucose levels were measured by glucometer every 12 hours starting from admission until 48 hours during ICU stay. Gastric residual volume was measured every 4 hours (gastric residue was collected in an empty container and its volume was measured). All parameters measured were divided into two categories: hyperglycemia (if there was at least once blood glucose level >180 mg/dL) and euglycemia (if blood glucose levels were \(\leq 180\) mg/dL); high gastric residual volume (if there was at least once gastric residual volume >125 mL found) and normal (if gastric residual volume was \(\leq 125\) mL in each measurement); hypokalemia (serum potassium level was <3.5 mmol/L measured during this study) and normo/hyperkalemia (serum potassium levels were normal or >5.5 mmol/L); low MAP status (if there was at least once MAP level <65 mmHg) and normal MAP status (if MAP levels were \(\geq 65\) mmHg); “yes” (if any opioid medication or catecholamine was used) and “no” (if it was not used).

Data were analyzed using Statistical Package for Social Science (SPSS) version 20.0. The Kolmogorov-Smirnov test of normality was used for age, weight, BMI, and calorie intake. Numerical data that are normally distributed will be shown in mean ± standard deviation (SD); and in median (minimum–maximum value) if otherwise. Categorical data will be shown in distribution and frequency. The relationship between hyperglycemia and high gastric residual volume were analyzed using Chi-Square test.

**RESULTS**

Within 10 weeks of the study, 104 subjects were collected. There were 96 subjects analyzed. There were 8 subjects who were dropped out from this study: 2 subjects had their enteral tube removed and 6 subjects passed away before 48 hours.

Baseline characteristic of the subject are shown in Table 1 and 2. Percentage of hyperglycemia and high gastric residual volume status are shown in Figure 1. Analysis of relationship between hyperglycemia and high gastric residual volume of this study is shown in Table 3. There was no significant relationship between hyperglycemia status and high gastric residual volume in the first and second 24 hours of admission.
Additional analysis was done to determine the possibility of time needed to develop into high gastric residual volume from the time hyperglycemia was detected. There are 12 subjects who had high gastric residual volume after hyperglycemia was detected. The analysis showed the mean time measured was 19.67 ± 11.06 hours.

**Blood Glucose Level dan Gastric Residual Volume Status**

There was a significant decrease of hyperglycemia percentage (>10%) in second day of admission in ICU compared to first day. This could mean that hyperglycemia was promptly managed. In this ICU, management of hyperglycemia is done with strict glucose control by insulin starting from blood glucose >180 mg/dL. This cut off point is based on ASPEN Clinical Guidelines.  

The proportion of hyperglycemia in this study is lower compared to other studies by Van den Berghe et al 4 (12%) and Cely et al 5 (38%). This can be due to higher blood glucose cut-off point in both studies (>200 mg/dL).

There was no significant decrease of subjects with high gastric residual volume status in this study. This number also does not differ significantly compared to study by Junizar et al 15 (23.3%). The number of subjects with high gastric residual volume in this study is lower compared to studies by Mentec...
et al\textsuperscript{14} (32\%) and Metheny et al\textsuperscript{16} (72.8\%) which can be due to different cut-off point and frequency of measurement used in both studies.

The relationship between hyperglycemia and high gastric residual volume

The results showed no significant relationship between hyperglycemia and high gastric residual volume in both first and second 24 hours of admission in ICU. These results were similar with a study by Mentec et al\textsuperscript{14} which found no significant difference of blood glucose level between subjects with high and normal gastric residual volume. The result of this study differs from a study by Nguyen et al\textsuperscript{10} which found high gastric residual volume was associated with hyperglycemia. The difference of the results may due to difference in the studies objectives and blood glucose measurement frequencies.

Additional analysis was done to determine the possibility of time needed to develop into high gastric residual volume from the time hyperglycemia was detected. The analysis of 12 subjects with high gastric residual volume occurred after hyperglycemia showed the mean time measured was 19.67 ± 11.06 hours. A study by Nguyen et al\textsuperscript{10} showed critically ill patients who are intolerant of enteral feeding had a trend for higher blood glucose levels on admission and had greater variation in blood glucose levels, especially 24 hours prior to enteral feeding intolerance. However, in this research, the analysis can not be concluded due to lack of numbers of subject. Therefore, further research with case control or longitudinal method is needed to determine this issue.

No relationship between hyperglycemia and high gastric residual volume in this study could be due to the length of study time, blood glucose level measurement frequencies and management of hyperglycemia in subjects. Longer time is probably needed to observe the effect of hyperglycemia to gastric residual volume. In this study, blood glucose level measurements done other than every 12 hours were not included in the analysis. Therefore, there were possibly more subjects who had hyperglycemia. In addition, the prompt management of hyperglycemia in this study possibly hindered the high gastric residual volume to develop. For those reasons, further research using case control or longitudinal method is needed. Using more frequent blood glucose level measurements or continuous blood glucose monitoring is suggested in further research.

There are limitations to this study. This study did not examine disease severity and more specific diagnosis of the subjects in which would possibly affect gastric emptying rate. Data were only collected within two days, therefore it may be too short to observe the effect of hyperglycemia to gastric residual volume. Blood glucose level was measured every 12 hours, therefore any hyperglycemia occurred beyond those time could be missed. The design of this study could also become a limitation. We used cross sectional study, whose
data was divided categorically, to determine the relationship because high gastric residual volume was expected to happen concurrently with hyperglycemia onset or after hyperglycemia occurred. Diabetic patients were not excluded, which could also affect the outcome of this study. Gastric emptying disorder frequently occurs in patients with chronic diabetes mellitus.

In conclusion, there was no significant relationship between hyperglycemia status and high gastric residual status in this study. Further research with more frequencies of blood glucose measurements or using continuous blood glucose monitoring is needed to better determine the hyperglycemia status in critically ill patients. Further research is also needed to determine whether episodic or chronic hyperglycemia can cause high gastric residual volume much later, and also observation on the average time from the beginning of hyperglycemia to develop into high gastric residual volume is needed.

Conflicts of Interest
Authors declared no conflict of interest regarding this study.

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