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Gastric Residual Volume Linked to Gastric Fluid pH in Infants with Very Low Birth Weight

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Abstract: Limited information exists regarding the correlation between gastric residual volume and gastric fluid pH before feedings in infants with very low birth weight. The purpose of this study was to evaluate this relationship in infants with feeding tolerance compared with that in those with feeding intolerance. A total of 86 infants with very low birth weight were included in the study, including 43 with feeding tolerance (study group) and 43 with feeding intolerance (control group). Gastric residual volume was obtained using a feeding tube and acidity measured using a pH-test paper. The gastric fluid pH was measured before each feeding in both the groups and compared. Demographic and clinical characteristics were similar between very low birth weight infants with and without feeding intolerance. Significant differences were observed in the gastric fluid pH between groups ($p < 0.05$). The gastric fluid pH value significantly increased with increasing gastric residual volume in a linear fashion (Pearson correlation = 0.543; $P < 0.05$). There is a positive linear correlation between gastric residual volume and gastric juice pH value in infants with very low birth weight.

Keywords: Very Low Birth Weight Infants, Feeding Intolerance, Gastric Residual Volume, Gastric Fluid pH

1. Introduction

Adequate nutrition is most important for the optimal growth and health of a very low birth weight [1-2]. However, feeding intolerance (FI) is the most common gastrointestinal condition seen in infants with very low birth weight (VLBW) during enteral nutrition and usually results in withholding of enteral nutrition for a period that negatively affects the infants' growth process [3]. FI is usually defined as gastric residual volume (GRV) > 50% of the previous feeding volume; emesis, abdominal distension, or both of these symptoms; and a decrease, delay, or discontinuation of enteral feedings [3-6]. Gastric residuals (GRs) are evaluated in preterm infants who are being fed via an orogastric or nasogastric tube as a putative indicator of FI or as an early symptom of necrotizing enterocolitis [7-8]. Although GRV is not an important predictor of early NEC, it is not recommended to check gastric residuals routinely. Only check pre-feed gastric residual volume (GRV) only after a minimum feed volume (per feed) is attained [1]. The digestive capacity of the stomach is mainly affected by gastric acid. Normal gastric acidity can be affected by various factors including food in the digestion process, mouth and stomach secretions, and duodenal contents getting mixed with stomach fluid [9]. The average gastric pH level for proteolytic activity should be between 2 and 3 [9-11]. Limited information exists regarding the correlation between GRV and gastric fluid pH before feedings in VLBW infants. The purpose of this study was to evaluate this correlation in infants with feeding tolerance or FI.

2. Material and Methods

We assessed 86 cases of VLBW infants (46 boys and 40 girls) born between January 2011 and September 2015 at our hospital. This study was approved by the Hospital Ethics Committee, and consent was provided by the family of the

VLBW infants included in the study.

Inclusion criteria were birth weight < 1500 g; gestational age < 32 weeks; enteral feeding initiated 12-48 h after birth; and no obvious abnormal appearance and chromosome abnormality. Subjects were excluded from the study if they had severe asphyxia (Apgar score < 3 points). Forty-three VLBW infants were diagnosed with FI and included in the study group, and 43 VLBW infants without FI were included in the control group.

FI diagnostic criteria consisted of at least one of the following: distention, vomiting more than half of the feeding amount repeatedly, and/or half of the feeding amount as the residual before the next feeding [3]. 2 NICU nurse practitioners, specifically trained in pH testing and pH strip interpretation, collected the samples and performed the test at each patient's bedside using SSS pH indicator strips. The pH values were obtained by measuring the gastric fluid using pH test paper. Two colorimetric pH tests were used to increase the reliability of the pH measurements of the feeding tube aspirates.

Statistical analyses were performed on demographic characteristics of the groups, as well as pH values, and evaluated the patient group as tolerance and intolerance. Statistical data were processed in SPSS Statistics using the t-test for independent variables, chi-square for dependent variables, and Linear Regression analysis for the correlation with GRV and gastric fluid pH in the VLBW infants with feeding tolerance and FI. A p value of < 0.05 was considered statistically significant.

3. Results

3.1. Patient Demographics

Overall, patient demographics, including gestational age, birth weight, sex, cesarean section, preeclampsia, prenatal steroids, duration of tube feeding, and duration of hospitalization, were similar between groups. No statistically significant differences were observed between groups (P > 0.05) (Table 1).

Table 1. *Clinical and Demographic Characteristics of Study Population (N=86).*

	Control group (n=43)	Patient group (n=43)	[a] χ^2 value. [b] *t* value	*P* value
Gestational age (weeks)	29.93±2.04	30.42±2.03	1.11 [b]	0.26
Birth weight (g)	1195.01±193.02	1187.11±180.03	0.21 [b]	0.84
Gender boys (%)	24 (56.0)	25 (58.0)	0.047 [a]	0.82
Cesarean section, n (%)	26 (60.5)	27 (62.8)	0.049 [a]	0.82
Preeclampsia, n (%)	10 (23.3)	11 (33.3)	0.950 [a]	0.33
Prenatal steroids, n (%)	38 (88.4)	37 (86.0)	0.100 [a]	0.75
Duration of tube feeding (d)	25.55±12.25	26.13±13.23	0.20 [b]	0.85
Duration of hospitalization (d)	37.74±16.41	38.12±16.31	0.10 [b]	0.91

3.2. pH Values

Statistically significant differences were observed between the study and control group. In particular, we found that infants who were FI had significantly higher pH values, compared with infants who were not (Table 2).

Table 2. *Comparison of gastric fluid pH values between groups.*

	n	gastric fluid pH	*t* value	*P* value
Control group	43	3.05±0.65		
Study group	43	4.98±0.98		
			10.74	0.00

3.3. Linear Correlation Between GRV and Gastric Fluid pH

We found that pH values of the gastric fluid significantly increased with increasing GRV (Pearson correlation = 0.543; P < 0.05); the relationship was linear. In addition, we found a significant positive linear correlation between GRV and gastric juice pH value (R^2=0.295, F=34.71, P<0.05) (Figure 1).

4. Discussion

4.1. Higher pH Values FI Infants

Because VLBW infants tend to have underdeveloped oral motor skills and cannot coordinate the simultaneous actions of sucking, swallowing, and breathing, they are most often fed by gavage. The placement of the orogastric feeding tube is confirmed before each feeding and the gastric contents are aspirated from the stomach. GRV is the volume of feeding extracted from the preterm infant's stomach via the orogastric tube to determine undigested volume before administering the next feeding [3, 12]. Despite Although studies showing that GRV is not correlate with the ability to reach full-feeding volumes and that variations exists for the exact GRV providers tolerate before stopping feeds, providers continue to use GRV as a clinical manifestation of feeding intolerance [5]. The GRV most agreed upon was > 50% of prior feed volume. Although GRV is not an important predictor of early NEC, it is not recommended to check gastric residuals routinely. Only check pre-feed gastric residual volume (GRV) only after a minimum feed volume (per feed) is attained [1]. The majority of preterm infants secrete acid in quantity sufficient to maintain the gastric pH at ≤ 4, providing a barrier to bacteria and protein antigens. In our study, we found that the mean gastric fluid pH values in VLBW infants with FI were significantly higher than in those with feeding tolerance (Table 2).

Gastric pH is lower in full-term infants than in preterm infants [9]. One recent study demonstrated that the gastric pH levels in preterm infants with FI was lower than gastric pH levels of full-term infants with FI [13]. Other studies have shown a significantly lower (more acidic) fasting and higher (more alkaline) postprandial gastric fluid pH in preterm infants after feeding [14, 15]. Although the exact mechanism

of action is unclear, higher (more alkaline) intolerance gastric fluid pH could explain the large number of gastric retention leading to dilute acid.

4.2. Gastric Remnant of VLBW Infants Is Positively Correlated with the pH Value of Gastric Juice

VLBW infants frequently experience what is clinically described as FI because of intestinal immaturity and decreased intestinal motility. In our study, we also found GRs of VLBW infants were positively correlated with the pH value of gastric juice. When GRV > 50% of the previous feeding volume (the patient group), we observed a higher (more alkaline) gastric fluid pH. The greater the gastric residue, the higher the pH value of gastric juice; a linear positive correlation was observed (Figure 1). In these studies, pH value has been reported as minimum of 2 (prior to feeding) and maximum 8 (post-feeding) [14, 15]. We observed a gastric pH level difference between the two groups in pre-feeding periods. Omari and Davidson [16] reported that after feeding with breast milk or formula, the median gastric pH increased quickly from 6.0 to 7.0 in 30 min, then decreased from 4.5 to 5.0 at 60 min, and reached a basal level of 1.5-3.0 at 120 min at the midpoint of the stomach in preterm infants. The majority of preterm infants secrete acid in quantity sufficient to maintain the gastric pH at ≤ 4, providing a barrier to bacteria and protein antigens. As the infants become more mature, in terms of gestation and postnatal age, a decrease in gastric pH occurs, which represent an increased maturation of the gastric function [9, 17]. It should be noted that this study only examined the correlation between gastric fluid pH and GRV. We only focused on only gastric fluid pH and did not examine the correlation between gastric fluid pH and FI. Further research studies, including well-designed, randomized controlled trials, are warranted to elucidate these issues.

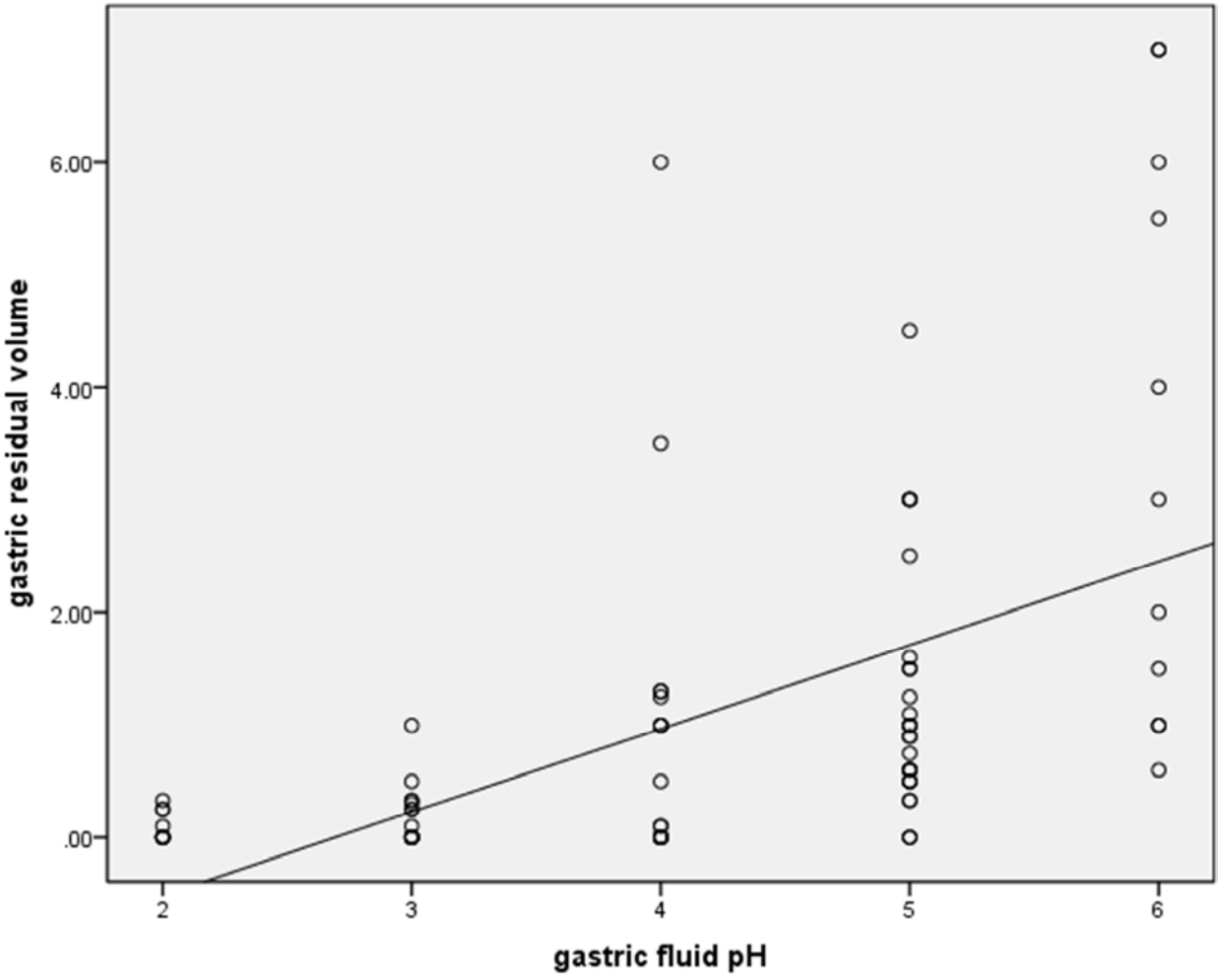

Figure 1. *Analysis of the linear correlation between gastric residual volume and gastric juice pH value.*

5. Conclusion

There is a positive linear correlation between gastric residual volume and gastric juice pH value in infants with very low birth weight.

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