Usefulness of Mean Gastric Emptying Time in Late Preterm and Term AGA and SGA Newborns to Determine Feeding Frequency—An Observational Study

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Abstract

Objectives: The primary objective is to calculate and compare mean gastric emptying time in appropriate for gestational age (AGA) and small for gestational age (SGA) newborns. The secondary objective is to compare mean gastric emptying time in SGA babies with or without antenatal Doppler changes and to measure gastric spheroidal volume at various intervals in AGA and SGA newborns with or without antenatal Doppler changes.

Methods: This prospective observational study was carried over 3 months from November 2022 to January 2023. A total of 30 newborns were enrolled and their gastric spheroidal volume was calculated by ultrasound pre-feed and post-feed every 30 minutes till it reached within 10% of pre-feed volume which was taken as gastric emptying time. Mean gastric emptying time was compared among AGA and SGA newborns and amongst SGA with or without antenatal Doppler changes.

Results: Mean gastric emptying time of AGA was 124 ± ± 25.01 minutes and for SGA was 132 ± 29.57 minutes which was statistically nonsignificant. Mean gastric emptying time when compared between SGA neonates with or without antenatal Doppler changes was similar (*P* value .43). The gastric spheroidal volume was significantly smaller in SGA newborns compared to their AGA counterparts in pre-feed state (*P* value .01) and it persisted till 60 minutes post feed (*P* value .028); however, the mean gastric emptying time is similar in both the groups.

Conclusion: Mean gastric emptying time of AGA and SGA newborns is similar and hence a feeding interval of 1.5 to 2.5 hours is appropriate for these late preterm and term newborns. Antenatal Doppler changes in SGA babies did not alter their gastric emptying time hence similar feeding frequency can be used in both.

Keywords

Gastric emptying time, ultrasound, gastric spheroidal volume, SGA, neonate

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Introduction

Feed tolerance and feeding frequency in neonates are mostly decided by subjective consensus by most neonatologists. All neonates are different individuals so their gastric volumes can be different, which leads to changes in gastric emptying time. Hence, a common yardstick of feeding every 2 hours or 3 hours may not hold true for all newborns. There is a need for an objective assessment in deciding the feeding frequency in all newborns. This is of even more importance in small for gestational age (SGA) neonates as there is a common practice of withholding feeds for small gastric residual volume due to fear of feed intolerance and gut ischemia. In contrast, it has also been observed by many that feeds can be started on Day 1 itself for SGA babies with no increase in cases of feed intolerance or vomiting. However objective data of practice is unavailable.

The clinical methods used for defining feed intolerance are pre-feed gastric residual volume and abdominal girth measurements, both of which are not always accurate in assessing feed intolerance. An objective way of defining feed tolerance and frequency is measurement of gastric emptying time which is defined as time taken for liquid or solid (food particles) to pass through the stomach and measured by radionuclide scintigraphy or ultrasound (USG) estimation of antral

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cross section areas or gastric spheroidal volume of newborn. USG measurement is noninvasive and better visualization of stomach contents is possible. Gastric emptying time has potential in becoming an objective tool in deciding feed frequency in newborns.

There is lack of evidence to justify current feeding practices, and the optimal time interval to feed late preterm and term SGA newborns is unknown. This study was planned to answer the question whether gastric emptying time calculated by ultrasonography can be used as an objective assessment tool to decide the interval of feeds in newborns, and to compare appropriate for gestational age (AGA) newborns gastric emptying time with SGA newborns with or without antenatal Doppler changes.

Materials and Methods

The prospective observational study was carried out in a Level III NICU of North India over a period of 3 months from November 2022 to January 2023. An informed consent was obtained from the neonate's attendants and those willing were enrolled (Figure 3). The study was initiated after obtaining approval from the Institutional Research Committee and Institutional Ethics Committee (Neonatology/2023/01).

Primary objective: To calculate and compare mean gastric emptying time in AGA and SGA newborns.

Secondary objective: To compare mean gastric emptying time in SGA babies with or without antenatal Doppler changes and to measure gastric spheroidal volume at various intervals in AGA and SGA newborns with or without antenatal Doppler changes.

Inclusion criteria: Late pre-term (34 0/7 to 36 6/7 completed weeks of gestation) and term (37 0/1 to 41 6/7 completed weeks of gestation) live births whose hospital stay exceeded 72 hours.

Exclusion criteria: Newborns suffering from comorbidities such as RDS, perinatal asphyxia, NEC, sepsis, hypoglycemia, hypothermia, polycythemia, congenital malformations; on formula feeds; on medications affecting gastric emptying time (e.g., inotropes, caffeine, erythromycin, and domperidone), multiple pregnancies, and parents/attendants who refused consent.

Methodology

All consecutively eligible neonates whose parents/attendants gave consent were enrolled in study and underwent the USG evaluation between 72 and 120 hours of life. This time period was selected to obtain better images on USG for which feed volume of minimum 100 ml/kg is required, which is usually achieved after 72 hours of life.[1] Newborns were fed with mother's own milk or donor human milk prior to obtaining the USG image. A baseline vitals including heart rate, spO2 was obtained from a pulse-oximeter with signal extraction technology (MASIMO Radical 7). Sonosite Edge II USG machine and a C60xi (5-2 MHz) curved transducer probe was used to calculate stomach volume. USG examination was done by principal investigator (PI) who is a fellow in neonatology. PI underwent 8 weeks training in radiology for the various views from a radiologist (coauthor of the study). All the images were reviewed by neonatologists trained in point of care USG and by radiologist. USG gel was pre-warmed and transducer disinfected using 80% Isopropyl alcohol wipes before each examination. The transducer was placed perpendicular to the left lateral chest wall and rotated to allow a clear view of the spleen while the stomach was at its largest diameter and length (longitudinal plane) in order to gather pictures for the computation of stomach volume. A transverse view was obtained by taking a second image with the transducer perpendicular to the longitudinal plane. Due to the newborn's stomach's elevated posture, the intercostal technique was used to scan them. Anterior-posterior diameter (D1), transverse diameter (D2), and longitudinal diameter (D3) calculations were made using the on-screen calipers, and the spheroidal volume of the stomach was computed using the built-in calculator of the USG machine (Figure 1a–1d). Spheroidal volume was calculated pre-feed and immediately post-feed followed by every 30-minute interval till next feed or 3 hours whichever was earlier.

$$\text{Spheroidal Volume} = \text{AP diameter} \times \text{Transverse diameter} \times \text{Longitudinal diameter} \times 0.52$$

Gastric emptying time was defined as time taken for gastric spheroidal volume to reach back within 10% of its pre-feed volume.[1-3] Feed Interval was defined as time equal to calculated gastric emptying time.

Babies were comforted using expressed breast milk swabs, dextrose 25% solution swabs or swaddling during USG procedure. If any neonate developed clinical deterioration in form of desaturation (SpO_2 <85%), bradycardia (HR <100/min), or tachycardia (>180/min), then the examination was stopped to allow physiological normalization of the newborn. No sedation was used during USG examination.

Sample size: Previous studies by Lee et al[3] and Perella et al[4] estimated a gastric emptying time of 92.9 ± 42.6 mins. Using Cochran formula for an observational study and 1.96 z value for 95% significance level, SD = 42.6, E = ± 20 min, a minimum sample size of 18 was obtained. A total of 30 (15 AGA neonates and 15 SGA) neonates was enrolled in our study.

Statistical methods: Continuous variables are presented as mean ± SD, and categorical variables presented as absolute numbers and percentages. Data was checked for normality by the Kolmogorov-Smirnov test before the statistical analysis. Normally distributed continuous variables were compared using the unpaired t-test, while Mann-Whitney U test was used for those variables that were not normally distributed. Categorical

Figure 1a. Dual Screen Mode: Stomach Volume Calculated as D1/D2/D3—Longitudinal/Transverse/AP Diameter.

Figure 1b. AP and Transverse Diameter of Stomach in Single Screen Mode.

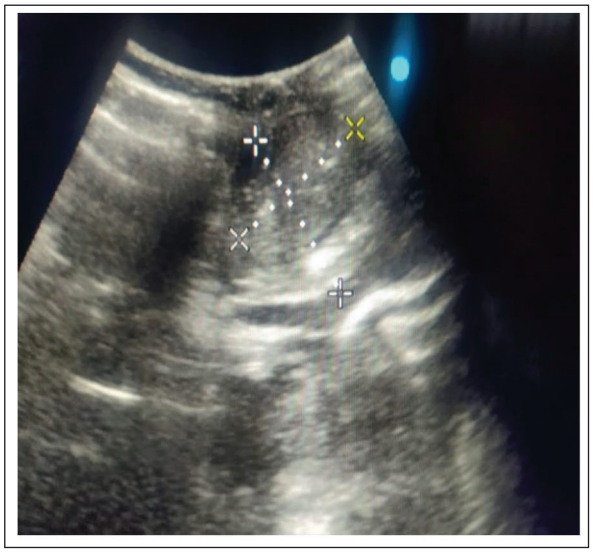

Figure 1c. Single Screen Mode of AP and Transverse Diameter of Stomach 30 Min Post-feed Interval.

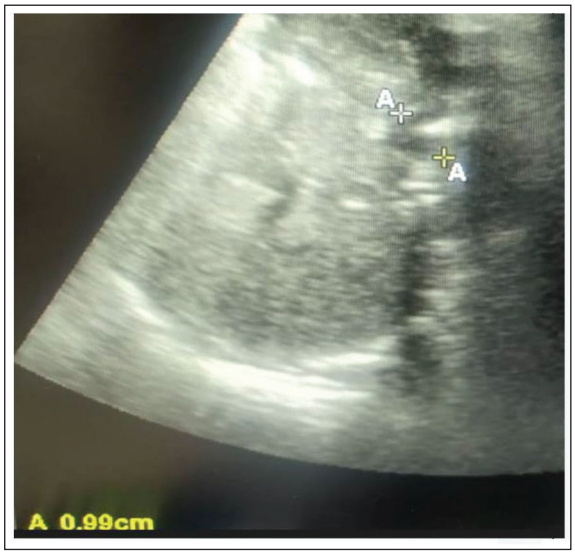

Figure 1d. Image Depicting Pre-feed Stomach.

variables were analyzed using either the chi-square test or Fisher's exact test and continuous variables by ANOVA test. A *P* value of <.05 was considered statistically significant. The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences version 20.

Results

Baseline characteristics (Table 1) were comparable except for birth weight. Mean gastric emptying time of AGA was 124 ± 25.01 minutes and for SGA was 132 ± 29.57 minutes which was statistically nonsignificant (Table 2). The average for these 2 groups is 128 ± 27.22 minutes, hence a feeding interval of 1.5 to 2.5 hours can be used in these neonates. Mean gastric emptying time when compared between SGA neonates with or without antenatal Doppler changes (Table 3) was similar (*P* value .43). The gastric spheroidal volume (Table 4, Figure 2) was significantly smaller in SGA newborns compared to their AGA counterparts in pre-feed state (*P* value .01) and it persisted till 60 minutes post-feed (*P* value .028); however, the mean gastric emptying time is similar in both the groups.

Discussion

In our study, 15 AGA and 15 SGA newborns were included and compared for various parameters like pre-feed and

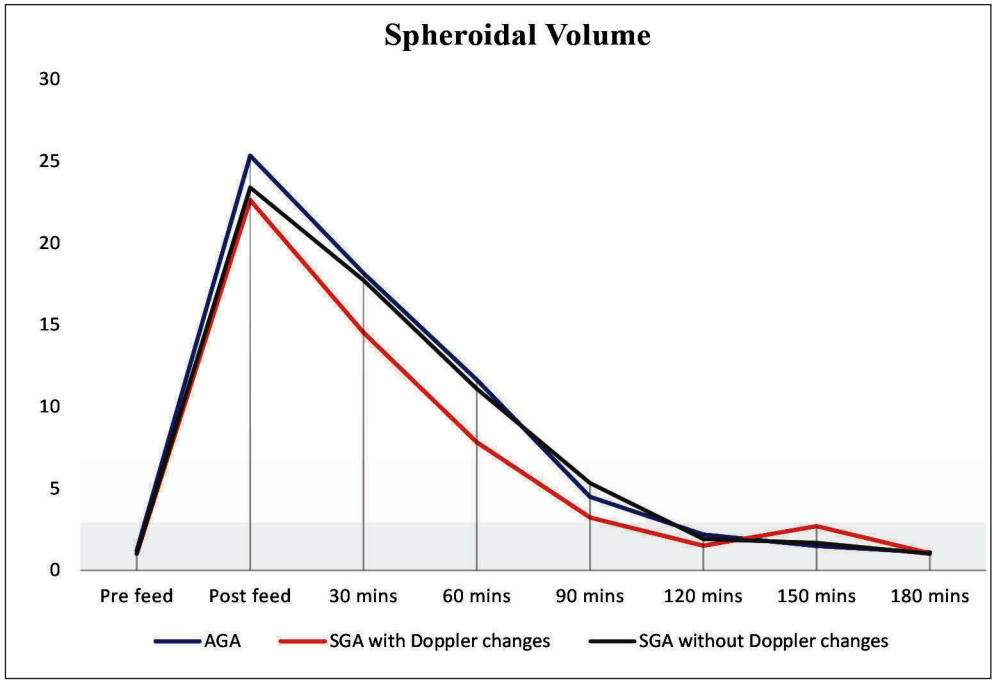

Figure 2. Comparison of Gastric Spheroidal Volume at Various Time Intervals in AGA Newborns with SGA Newborns (With/Without Antenatal Doppler Changes).

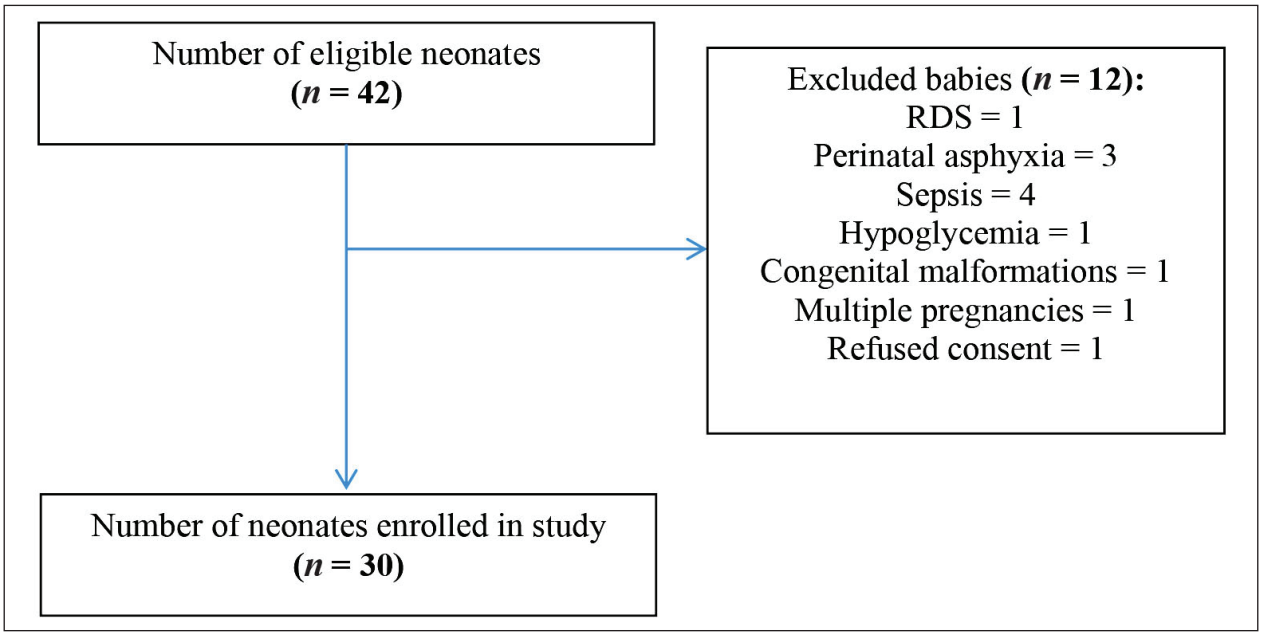

Figure 3. Flowchart Depicting Enrollment of Babies in the Study.

post-feed gastric spheroidal volume and mean gastric emptying time.

The mean pre-feed stomach volume of AGA newborns was 1.2 ± 0.14 cm^3 while for SGA newborns without antenatal Doppler changes was 1.02 ± 0.2 cm^3 (P .009) and for SGA newborns with antenatal Doppler changes it was 1.04 ± 0.11 cm^3 ($P < .019$). This reveals a significant smaller gastric volume in SGA newborns in the pre-feed state.

Table1. Baseline Characteristics.

Characteristics	AGA (*n* = 15)	SGA (*n* = 15)	*p* Value
Gender Male n (%)	5 (33.33)	9 (60)	.33
Gestation(weeks) (Mean ± SD)	38.6 ± 1.2	38.1 ± 1.5	.32
Term Gestation n (%)	13(86.6%)	11(73.3%)	–
Late preterm Gestation n (%)	2(13.4%)	4(26.7%)	–
Birth weight (grams) (Mean ± SD)	3090.87 ± 364.46	2170.53 ± 203.93	<.001
Day of life (days) (Mean ± SD)	3.8 ± 0.94	3.73 ± 0.8	.97

Table 2. Comparison of Gastric Emptying Time in AGA vs SGA Newborns.

	AGA (*n* = 15) (Mean ± SD)	SGA (*n* = 15) (Mean ± SD)	*p* Value
Gastric emptying time (minutes)	124 ± 25.01	132 ± 29.57	.43

Table 3. Comparison of Gastric Emptying Time in SGA Newborns (With or Without Antenatal Doppler Changes).

	SGA With Doppler Changes (*n* = 8) (Mean ± SD)	SGA Without Doppler Changes (*n* = 7) (Mean ± SD)	*p* Value
Gastric emptying time (minutes)	120 ± 27.77	145.71 ± 26.99	.09

Table 4. Comparison of Gastric Spheroidal Volume in AGA vs SGA Newborns.

Time Interval	AGA (*n* = 15) (Mean ± SD)	SGA With Doppler Changes (*n* = 8) (Mean ± SD)	SGA Without Doppler Changes (*n* = 7) (Mean ± SD)	*p* Value
Pre-feed	1.2 ± 0.14	1.04 ± 0.11	1.02 ± 0.2	.01
Post-feed	25.35 ± 2.08	22.63 ± 1.58	23.4 ± 1.6	.005
30 mins	18.16 ± 3.61	14.54 ± 1.94	17.73 ± 2.69	.03
60 mins	11.65 ± 3.7	7.83 ± 2.04	11.1 ± 2.71	.028
90 mins	4.49 ± 3.17	3.23 ± 2.41	5.34 ± 1.62	.32
120 mins	2.19 ± 1.63	1.51 ± 1.32	1.92 ± 1.09	.31
150 mins	1.49 ± 0.53	2.7	1.68 ± 0.94	.17
180 mins	1.1	1.05	1.02 ± 0.28	

Note: Gastric spheroidal volume is measured in cm^3. *p* value signifies difference between three groups.

Similar findings were noted in few other studies,[5-7] although a direct comparison of AGA vs SGA newborns could not be found for this dataset.

The mean post-feed gastric volume of AGA newborns was 25.35 ± 2.08 cm^3, 23.4 ± 1.6 cm^3 for SGA newborns without antenatal Doppler changes and 22.6 ± 1.58 cm^3 for SGA newborns with antenatal Doppler changes. A significant post-feed gastric volume persisted till 60 minutes (*P* .028). This reveals that a significant smaller volume persists for one-hour post-feed in SGA newborns. Similar findings of stomach volume were noted in few studies,[1,2] though a direct comparison of AGA vs SGA newborns was not available.

Mean gastric emptying time was similar when compared between AGA and SGA newborns (124 ± 25.01 minutes and 132 ± 29.57 minutes, *P* .43). The average gastric emptying time in these 2 groups was 128 ± 27.22 minutes which is lower than gastric emptying time calculated by Beck et al[8] (218 minutes) and higher than gastric emptying time calculated by Lee et al[2] (45–150 mins, averaged 92.9 minutes). However, it is quite similar to Perella et al[4] (120–180 mins).

The pre-feed and post-feed gastric volume is statistically significantly smaller in SGA newborns; however, the gastric emptying time is similar. Hence, a feeding interval of 1.5 to 2.5 hours can be used in these subset of newborns.

Gastric emptying time was statistically nonsignificant when SGA newborns with antenatal Doppler changes was compared with those without these changes (120 ± 27.77 minutes and 145 ± 26.99 minutes, *P* .09). Hence, antenatal Doppler change should not change feeding interval practice in this subset of newborns. No similar study was available for comparison with this study finding.

The limitations of our study remain the small sample size. In addition, a time gap of 30 minutes between calculations of gastric emptying time was taken for practical purposes but a shorter time gap interval may have given more accurate results. Also a smaller SGA neonate could have been receiving smaller volume of feed compared to a larger AGA neonate leading to smaller pre-feed gastric spheroidal volume and can partly explain the difference in the stomach volume observed between the 2 groups. Another limitation was that we did not document a kappa value at the time of the study, which could have provided an inter-rater agreement leading to a better estimate of the outcomes. Hence, these results of our study are only applicable to similar neonates and not generalizable to all newborns. A well-designed randomized controlled trial with inclusion of a larger sample size and more representative neonates (preterm ≤ 34 weeks with or without comorbidities), with one group fed as per standard feeding regimen and the other group fed by USG guided gastric emptying time, can provide optimum feeding frequency in these newborns.

Conclusion

Mean gastric emptying time of AGA and SGA newborns is similar and hence a feeding interval of 1.5 to 2.5 hours is appropriate for these late preterm and term newborns. Antenatal Doppler changes in SGA babies did not alter their gastric emptying time; hence, similar feeding frequency can be used in both.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

The study was initiated after obtaining approval from the Institutional Research Committee and Institutional Ethics Committee (Neonatology/2023/01).

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Informed Consent

The participant has consented to the submission of the article to the journal.

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