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COMPARISON OF FENTON AND INTERGROWTH-21 CHARTS FOR EVALUATING POSTNATAL GROWTH IN VERY LOW BIRTH WEIGHT PRETERM INFANTS: A RETROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT **Objectives** To compare postnatal growth classifications in very low birth weight (VLBW) preterm infants using Fenton and Intergrowth-21 charts and to examine associations between extrauterine growth restriction (EUGR) and risk factors such as sepsis and delayed feeding. **Methods** This retrospective study included 279 VLBW preterm infants (<1.5 kg, <37 weeks) admitted from December 2022 to November 2023. Birth and discharge weights were plotted on Fenton and Intergrowth-21 growth charts to assess small for gestational age (SGA) and EUGR classifications. Chi-square tests analysed associations between EUGR and risk factors, with significance set at $p < 0.05$. **Results** The Intergrowth-21 chart classified more infants as SGA (39.7%) and EUGR (90.3%) than the Fenton chart (31.5% SGA, 85.6% EUGR). Sepsis was significantly associated with EUGR in both chart classifications. **Conclusion** The Intergrowth-21 chart may provide higher sensitivity for detecting growth restriction in VLBW infants compared to Fenton's. The association of sepsis with EUGR highlights the importance of infection control in promoting growth outcomes in this population.

KEYWORDS : Fenton chart, Intergrowth-21 chart, postnatal growth, preterm infants, extrauterine growth restriction, small for gestational age

INTRODUCTION

Growth assessment in very low birth weight (VLBW) preterm infants is crucial for ensuring appropriate clinical management and long-term health outcomes. Growth charts are widely used tools for this purpose, helping clinicians monitor and evaluate growth patterns in infants. Two prominent growth standards are the Fenton and Intergrowth-21 charts, each developed with different methodologies and populations in mind. The Fenton chart, based on a meta-analysis of data from six developed countries, represents intrauterine growth without adjustments for environmental or nutritional variations specific to individual populations.[1,2] In contrast, the Intergrowth-21 chart was created from a multiethnic, prospective study of uncomplicated pregnancies in optimal conditions, aiming to provide a global standard of healthy growth irrespective of environmental factors.[3]

Despite their widespread use, the differences between the Fenton and Intergrowth-21 charts can lead to varied classifications for small for gestational age (SGA) and extrauterine growth restriction (EUGR), potentially impacting clinical decisions. Understanding these differences is essential, as infants classified as growth-restricted may require closer monitoring and nutritional interventions to improve outcomes.[4]

In this study, we aim to compare the classifications of SGA and EUGR between the Fenton and Intergrowth-21 charts among VLBW preterm infants. Additionally, we examine the association between EUGR and key risk factors such as sepsis and delayed feeding. By exploring these factors, this study seeks to inform the selection of growth charts in clinical settings and support more accurate, timely identification of growth concerns in VLBW preterm infants.

MATERIALS AND METHODS

STUDY DESIGN AND SETTING

This retrospective observational study was conducted in the Pediatrics Department of Vani Vilas Hospital, Bangalore Medical College and Research Institute (BMCRI), a tertiary care centre in Bangalore, India. The study period spanned from December 2022 to November 2023, during which all eligible very low birth weight (VLBW) preterm infants admitted to the neonatal intensive care unit (NICU) were included for analysis.

STUDY POPULATION

The study focused on VLBW preterm infants, defined as those with a birth weight of less than 1.5 kg and a gestational age below 37 weeks. Inclusion and exclusion criteria were applied as follows:

INCLUSION CRITERIA:

All live-born VLBW preterm infants with gestational age under 37 weeks and birth weight below 1.5 kg.

Infants who were stable enough to be discharged with available data on discharge weight.

EXCLUSION CRITERIA:

Term infants (≥37 weeks gestational age) and infants weighing more than 1.5 kg at birth.

Infants with major congenital anomalies.

Infants who did not survive during their stay in the NICU, as these cases would not have discharge weights available.

Using these criteria, 279 VLBW preterm infants met the inclusion requirements and were included in the analysis.

DATA COLLECTION

Data were retrospectively collected from hospital birth and discharge records. The primary parameters extracted included birth weight, gestational age, and sex for each infant. Additional information on clinical risk factors, specifically the presence of sepsis and time to achieve full enteral feeds, was gathered to explore potential associations with extrauterine growth restriction (EUGR).

Sepsis was defined as a clinically diagnosed or laboratory-confirmed infection requiring antibiotic treatment.[5] Delayed achievement of full feeds was defined as the inability to reach full enteral feeding volumes (usually 120-150 mL/kg/day) within the first 10 days of life. These parameters were recorded to determine whether they had any impact on growth outcomes in the study population.

GROWTH ASSESSMENT

The Fenton and Intergrowth-21 growth charts were used as the two standards for evaluating postnatal growth. The Fenton growth chart, widely used in clinical settings, is based on a systematic review and meta-analysis of intrauterine growth data from developed countries, providing growth curves specific to preterm infants. The Intergrowth-21 chart, on the other hand, is derived from a multicentre, prospective study of healthy pregnancies across multiple countries and ethnic groups, aiming to reflect ideal growth patterns under optimal conditions.[6]

CLASSIFICATION CRITERIA

Infants were classified as small for gestational age (SGA) if their birth weight fell below the 10th percentile on either the Fenton or Intergrowth-21 chart. Extrauterine growth restriction (EUGR) was assessed at discharge, with discharge weights below the 10th percentile or less than -2 standard deviations (SD) on the respective chart being classified as EUGR.[7] Each infant's birth and discharge weights were plotted on both growth charts, and SGA and EUGR classifications were recorded accordingly.

STATISTICALANALYSIS

All collected data were entered into Microsoft Excel and subsequently analyzed using SPSS software (version 21, IBM Corp., NY, USA). Descriptive statistics were used to summarize demographic data, including frequencies and proportions for categorical variables such as SGA, EUGR, presence of sepsis, and feeding delay. Continuous variables, such as birth weight and discharge weight, were summarized using means and standard deviations. To evaluate the association between EUGR and clinical risk factors like sepsis and delayed achievement of full feeds, the Chi-square test was applied. This test was used to compare categorical data between groups (e.g., infants with and without EUGR on each growth chart) and to determine any statistically significant differences in risk factor prevalence. The level of significance was set at $p < 0.05$, meaning any p-value below 0.05 was considered indicative of a statistically significant association.

ETHICAL CONSIDERATIONS

Given that this study was retrospective and utilized de-identified data from existing hospital records, it posed minimal risk to participants. Ethical approval was obtained from the institutional ethics committee at BMCRI. The study adhered to ethical guidelines for research on vulnerable populations, ensuring the confidentiality and privacy of patient data.

SUMMARY OF THE METHODS

This study systematically analysed growth outcomes in VLBW preterm infants using both Fenton and Intergrowth-21 growth charts. The classification of SGA and EUGR was based on weight percentiles at birth and discharge. Clinical risk factors, specifically sepsis and feeding delays, were evaluated to determine their association with EUGR in this population. Statistical analysis was conducted to compare the two growth charts in identifying infants at risk, with the findings providing insights into the sensitivity and specificity of each chart in the context of a developing country setting.

RESULTS

SAMPLE CHARACTERISTICS

A total of 279 very low birth weight (VLBW) preterm infants were included in this study. The infants had a mean gestational age of 32 weeks (±2.1 weeks) and an average birth weight of 1.2 kg (±0.18 kg). The cohort was approximately evenly divided by sex, with 51% male and 49% female infants. All infants met the inclusion criteria of a birth weight under 1.5 kg and a gestational age below 37 weeks. Cases with major congenital anomalies or those who did not survive were excluded.

Table 1: Sample characteristics

		Frequency	Percentage
Gestational age	< 28 weeks	5	1.8%
	28- 32 weeks	158	56.6%
	32-34 weeks	72	25.8%
	34-37 weeks	44	15.8%
Sex	Male	125	44.8%
	Female	158	55.2%
Birth weight	<1 Kg	15	5.4%
	1-1.5Kg	264	94.6%

CLASSIFICATION OF SMALL FOR GESTATIONAL AGE (SGA)

When assessed using the Fenton growth chart, 88 infants (31.5%) were classified as small for gestational age (SGA) at birth, defined as having a birth weight below the 10th percentile for gestational age. In comparison, the Intergrowth-21 chart identified 111 infants (39.7%) as SGA. This indicates a higher sensitivity of the Intergrowth-21 chart in detecting infants with lower-than-expected birth weights in this cohort. The difference between the two charts in identifying SGA infants was statistically significant ($p < 0.05$), suggesting that the Intergrowth-21 chart may capture a broader range of infants at risk of growth restriction.

Table 2: Comparison of small for gestational age (SGA) between Fenton and Intergrowth-21 charts

	At birth	Frequency	Percent
Fenton	SGA	88	31.5%
	AGA	190	68.1%
	LGA	1	0.35%
Intergrowth-21	SGA	111	39.7%
	AGA	164	58.7%
	LGA	4	13.7%

SGA- Small for gestational age
AGA- Appropriate for gestational age
LGA- Large for gestational age

CLASSIFICATION OF EXTRAUTERINE GROWTH RESTRICTION (EUGR)

Extrauterine growth restriction (EUGR) was assessed based on discharge weights, with infants falling below the 10th percentile or -2 standard deviations on each growth chart classified as EUGR. On the Fenton growth chart, 239 infants (85.6%) were classified as experiencing EUGR by the time of discharge. When assessed with the Intergrowth-21 chart, 252 infants (90.3%) met the criteria for EUGR. The difference in EUGR classification between the two charts was statistically significant ($p < 0.05$), with the Intergrowth-21 chart identifying a larger proportion of infants as having growth restriction by discharge.

Table 3: Comparison of EUGR between Fenton and Intergrowth21 charts

	Frequency of EUGR(n)	Percent
Fenton	239	85.6%
Intergrowth 21	252	90.3%

COMPARISON BETWEEN FENTON AND INTERGROWTH-21 CHARTS

The higher rates of SGA and EUGR classification with the Intergrowth-21 chart suggest that it may be more sensitive in identifying growth restriction in VLBW preterm infants than the Fenton chart. For instance, the Intergrowth-21 chart classified 8.2% more infants as SGA and 4.7% more infants as EUGR than the Fenton chart. This pattern aligns with findings from other studies, which have reported that the Intergrowth-21 chart tends to classify more infants as growth-restricted due to its broader reference population and idealized growth standards.

Table 4: Accuracy of Intergrowth-21 with Fenton growth charts

EUGR - Fenton		EUGR- Intergrowth-21		Total
		Yes	No	
Yes	frequency	239	0	239
	%	85.6%	0%	85.6%
No	frequency	13	27	40
	%	4.7%	9.7%	14.4%
Total	frequency	252	27	279
	%	90.3%	9.7%	100%
Chi-square value-170.97				
p value- 0.0001*				

p-value < 0.05 is significant

RISK FACTOR ANALYSIS FOR EUGR

The study also examined the association between clinical risk factors—specifically sepsis and delayed achievement of full feeds—and the incidence of EUGR as defined by each growth chart.

SEPSIS

Fenton Chart: Among infants classified as EUGR using the Fenton chart, 154 (64.4%) had a documented diagnosis of sepsis during their NICU stay.

Intergrowth-21 Chart: Using the Intergrowth-21 chart, 163 infants (64.7%) with EUGR had sepsis.

The association between sepsis and EUGR was significant for both charts ($p < 0.05$), indicating that sepsis is a major risk factor for growth restriction in VLBW preterm infants.

DELAYED ACHIEVEMENT OF FULL FEEDS

Fenton Chart: Among infants classified as EUGR by the Fenton chart, 132 (55.2%) experienced delays in reaching full enteral feeds within the first 10 days of life.

Intergrowth-21 Chart: In the EUGR group identified by the Intergrowth-21 chart, 138 infants (54.8%) experienced feeding delays.

The association between delayed feeding and EUGR was weaker than that with sepsis, although it remained significant for both charts ($p < 0.05$). This suggests that while delayed feeding contributes to EUGR, it may not be as strong a factor as sepsis.

Table 5: Association of sepsis and delayed achievement of full feeds with EUGR- Fenton growth chart

			Fenton- EUGR		Total	Chi-square	P value
			No	Yes			
Sepsis	Present	Frequency	27	203	230	7.196	0.0073*
		%	9.7%	72.7%	82.4%		
	Absent	Frequency	13	36	49		
		%	4.7%	12.9%	17.6%		
Time to achieve full feeds	<7 days	Frequency	17	91	108	0.283	0.594
		%	6.1%	32.6%	38.7%		
	>7 days	Frequency	23	148	171		
		%	8.2%	53.1%	61.3%		

Table 6: Association of sepsis and delayed achievement of full feeds with EUGR- Intergrowth-21 growth chart

			IG21- EUGR		Total	Chi-square	P value
			No	Yes			
Sepsis	Present	Frequency	19	211	230	3.006	0.082
		%	6.8%	75.6%	82.4%		
	Absent	Frequency	8	41	49		
		%	2.9%	14.7%	17.6%		
Time to achieve full feeds	<7 days	Frequency	13	95	108	1.122	0.289
		%	4.7%	34%	38.7%		
	>7 days	Frequency	14	157	171		
		%	5%	56.3%	61.3%		

SUMMARY OF KEY FINDINGS

SGA Classification: 31.5% of infants were SGA according to Fenton, while 39.7% were SGA according to Intergrowth-21.

EUGR Classification: 85.6% of infants were EUGR on the Fenton chart, while 90.3% were EUGR on the Intergrowth-21 chart.

RISK FACTORS: Sepsis showed a strong association with EUGR in both charts ($p < 0.05$), with slightly higher prevalence in the Intergrowth-21 EUGR group. Delayed feeding was also significantly associated with EUGR, though less strongly than sepsis.

These results suggest that the Intergrowth-21 chart may offer a more sensitive assessment of postnatal growth restriction in VLBW infants, potentially guiding clinical practices toward more proactive interventions.

DISCUSSION

This study compared the Fenton and Intergrowth-21 growth charts for evaluating postnatal growth in very low birth weight (VLBW) preterm infants and analysed the association between extrauterine growth restriction (EUGR) and clinical risk factors, including sepsis and delayed feeding. Our results highlight key differences between the two charts in identifying growth-restricted infants, as well as the importance of clinical risk factors in the development of EUGR.

COMPARISON OF GROWTH CHARTS

The findings reveal that the Intergrowth-21 chart classified a significantly higher percentage of infants as small for gestational age (SGA) and EUGR compared to the Fenton chart. Specifically, 39.7% of infants were classified as SGA on Intergrowth-21 versus 31.5% on Fenton, and 90.3% were classified as EUGR on Intergrowth-21 versus 85.6% on Fenton. This aligns with prior research indicating that the Intergrowth-21 chart may be more sensitive in identifying growth restriction among preterm infants. For example, studies by Siyuan et al. and Starc et al. also reported higher rates of SGA and EUGR with Intergrowth-21 compared to Fenton.6,7 The Intergrowth-21 chart, which is based on an idealized sample population from healthy pregnancies across multiple countries, may capture a broader range of infants as growth-restricted, potentially due to its more stringent standards for optimal growth.

CLINICAL IMPLICATIONS

The higher sensitivity of the Intergrowth-21 chart may offer clinical advantages by allowing earlier identification of at-risk infants who could benefit from enhanced nutritional and medical support. This is particularly important in the VLBW population, where growth restriction is associated with adverse outcomes, including neurodevelopmental impairments, compromised immune function, and long-term metabolic issues.8 However, the use of Intergrowth-21 may also result in more infants being classified as growth-restricted than with Fenton, which could lead to increased resource utilization in neonatal care settings.

Given the differences between the charts, it is essential for clinicians to consider the context of their patient population when choosing a growth assessment tool. In settings with limited resources, the Fenton chart may provide a more practical balance between sensitivity and specificity. However, where feasible, adopting the Intergrowth-21 chart could enhance the accuracy of growth assessments, particularly in regions with access to advanced neonatal care and intervention options.[9,10]

RISK FACTOR ASSOCIATIONS

Sepsis emerged as a significant factor associated with EUGR in this study, supporting previous findings that infection in preterm infants can exacerbate growth delays.11 Sepsis contributes to systemic inflammation, increased metabolic demand, and reduced nutrient utilization, all of which can impede growth. Among infants classified as EUGR on both charts, more than 60% had a sepsis diagnosis, underscoring the importance of infection control in this vulnerable population.

Delayed achievement of full enteral feeds was also associated with EUGR, though less strongly than sepsis. Nutritional challenges are common in preterm infants, and delays in feeding milestones can impact growth outcomes. This study suggests that while timely feeding practices are important, addressing infections may be even more critical for preventing EUGR.

LIMITATIONS

The study's retrospective design is a limitation, as it relies on secondary data that may not capture all relevant variables, such as genetic and environmental factors. Additionally, the study was conducted in a single institution, which may limit the generalizability of the findings to other settings or populations with different socioeconomic and healthcare contexts.

CONCLUSION

In conclusion, this study supports the utility of the Intergrowth-21 chart for identifying growth-restricted VLBW infants, potentially enabling earlier interventions. The association of EUGR with sepsis highlights the need for comprehensive infection control and timely nutritional support to improve growth outcomes. Future studies could explore these findings in diverse settings to guide optimal growth assessment practices in neonatal care.

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