PERINATAL JOURNAL

Original Article

Perinatal Journal 2023;31(1):6–11

Comparison of Fenton and Intergrowth-21st growth charts: a retrospective study of preterm neonates at ≤34 weeks

Kirankumar Haridas, Manikumar Solaiappan, Muthukumaran Natarajan

Department of Neonatology, Chengalpattu Medical College and Hospital, Chengalpattu, Tamil Nadu, India

Abstract

Objective: To compare Fenton and Intergrowth-21st growth charts in assessing the growth pattern of preterm infants at birth and at discharge.

Methods: This is a retrospective study conducted over a period of 1 year. The study included the neonates born at ≤34 weeks of gestation who are admitted and stayed for ≥14 days in our hospital. The data was collected from discharge sheets and electronic database. The weight of all babies at birth and at discharge was collected. Growth was assessed based on Fenton and Intergrowth-21st growth charts. The small for gestational age (SGA) was defined as birth weight ≤-1.28SD. The extrauterine growth restriction (EUGR) status of babies was assessed by a criteria of ≤-1.28SD at discharge.

Results: Most common preterm phenotype was spontaneous preterm labor (47.4%), and the rate of singleton birth was 78.9%. The mean gestational age and birth weight of babies were 31.6±1.42 weeks and 1608.06±275 g, respectively. We found the rates of SGA in our group 15.2% and 13.5%, and appropriate for gestational age (AGA) 80.5% and 82.2%, respectively by using Intergrowth and Fenton growth charts. The EUGR rates in our group were 72.8% and 81.3%, respectively, on Intergrowth-21st and Fenton growth charts using a criteria of ≤-1.28SD at discharge.

Conclusion: There is no statistical difference between Fenton and Intergrowth-21st charts in identifying SGA and EUGR. However, the rate of EUGR is higher in Fenton charts than intergrowth-21st charts.

Keywords: Fenton, Intergrowth 21st, growth charts, preterm.

Introduction

The number of preterm infants born every year is around 15 million and it is on the rise. Preterm complications are the leading cause of death among children under 5 years of age accounting for around 1 million in 2015.[1] Those preterm infants who survive the neonatal period develop life-time disabilities including learning disabilities, vision and hearing deficits.

So it is necessary to closely monitor the growth in preterm infants to identify any deviations from the normal pattern. As of now, there are no ideal growth standard available for interpreting postnatal growth patterns of preterm infants. The current standards are based on the intrauterine growth status. But, there is no international consensus regarding how the growth of preterm neonates should be monitored or what is the ideal pattern of growth in these premature infants.[2]

Revised Fenton growth charts[3] published in 2013 were based on large preterm birth sample collected at different countries. They are used to assign the nutrition status of babies of gestational age till 36 weeks. The advantages of Fenton charts are that they included the data from recent population-based surveys from multiple countries and sex-specific data. They are equivalent to

Correspondence: Kirankumar Haridas, MD. Department of Neonatology, Chengalpattu Medical College and Hospital, Chengalpattu, Tamil Nadu, India.
e-mail: kkiranharidas@gmail.com / **Received:** December 5, 2022; **Accepted:** January 14, 2023

How to cite this article: Haridas K, Solaiappan M, Natarajan M. Comparison of Fenton and Intergrowth-21st growth charts: a retrospective study of preterm neonates at ≤34 weeks. Perinat J 2023;31(1):6–11. doi:10.2399/prn.23.0311002

ORCID ID: K. Haridas 0000-0001-8515-6124; M. Solaiappan 0000-0002-7262-2373; M. Natarajan 0000-0002-8674-6991

deomed

WHO growth curves at 50 weeks of post-menstrual age, so after this age, WHO growth curves can be used.[4] The disadvantages of these Fenton growth charts are that it is a growth reference and not growth standard, and it has variability in methods of measurements of growth parameters. The most important fact about Fenton growth charts is that they are not considering the postnatal physiological weight loss in the initial days of life and they are targeting an infant's birth percentile which is potentially harmful because it requires rapid weight gain and may cause harmful metabolic consequences in short-term and long-term as well.[3]

The recently published Intergrowth-21st growth charts are studied by International Fetal and Newborn Consortium with the objective to present prescriptive standards for growth between pregnancy and early infancy. Intergrowth-21st growth standards are developed from prospective study which is more reliable. The advantages of these growth charts are that they considered a large population from different ethnic groups and country. These are also sex-specific like Fenton charts.[5] The major disadvantage is that, in Intergrowth-21st preterm postnatal follow-up study, more than 80% of the preterm neonates were born at 34 weeks of gestation or later. Only few preterm neonates born at 33 weeks of gestation or earlier contributed data to the standard, and therefore, it cannot be considered as standard for infants born at <33 weeks of gestation.[6]

Although this growth-monitoring tool is based on a healthy preterm cohort and aims to provide a realistic and more appropriate international standard for monitoring of preterm infant's growth, its universal adaption has been limited by lack of studies that evaluate its performance and functional impact.

The growth of preterm infants is also adversely affected by neonatal morbidities such as necrotizing enterocolitis, gastrointestinal perforations, intraventricular hemorrhage, retinopathy of prematurity, and bronchopulmonary dysplasia. In addition, nutrition-related factors such as enteral feeding and parenteral nutrition practices can be significant risk factors for extrauterine growth restriction (EUGR). The very preterm infants are born with increased risk of extrauterine growth restriction.[2,7] The Vermont Oxford Network study reported that EUGR below the 10th percentile of weight by Fenton growth chart occurred in 50.3% of infants with very low birth weight (VLBW).[8]

In the present study, we hypothesized that the incidence of intrauterine and postnatal growth in preterm infants (≤34 weeks) might change when assessed with the new Intergrowth-21st growth standards compared with Fenton-2013 growth charts.

Methods

This is a retrospective observational study which was conducted in a tertiary care hospital. Our NICU is a tertiary care unit with 20 beds in level 3 and 30 beds in level 2 with annual admission rate of around 3000 infants. All babies who were born at ≤34 weeks of gestation and admitted to NICU and stayed for more than two weeks in the hospital were included in the study. The criteria of ≥14 days was considered as the infants during this period are still in physiologic weight loss and can catch up growth subsequently. Hence, these infants cannot be considered as growth restricted. Exclusion criteria used in the study were any baby born with major congenital anomaly or suspected chromosomal anomaly or syndrome. Infants died during hospital stay were also excluded from the study. Study included infants born between January and December 2019. The data was collected from case sheets and discharge summaries of babies who were admitted in neonatal intensive care unit (NICU), which were present in hospital medical records and in our electronic database (**Fig. 1**). Anthropometric measurement of weight was available for all infants at birth, and at the time of discharge. Two different references were used to asses appropriateness of growth: first one was Intergrowth-21st preterm size at birth and postnatal growth standards for preterm infants, and the second was Fenton 2013 growth charts. Birth weight and daily measurements of body weight in our unit were done using electronic weighing scales with accuracy of ±10 g. Z-scores for birth weight were calculated electronically using Fenton preterm growth charts[3] software accessed from https://live-ucalgary.ucalgary.ca/resource/preterm-growth-chart/preterm-growth-chart, and the Intergrowth-21st preterm size at birth[4] and postnatal growth standards[5] software accessed from http://intergrowth21.ndog.ox.ac.uk/en/Upload. Small for gestational age and large for gestational age were defined as less than or equal to -1.28SD (≤10th percentile) and more than or equal to +1.28SD (≥90th percentile) for gestational age, respectively.[9] The extrauterine growth restriction (EUGR) was defined by discharge weight of ≤-1.28SD (10th percentile).[10]

The feeding protocol used in our unit was initiating feeds at 30 ml/kg/day on day 1 in infants ≤1500 g and 60 ml/kg/day in infants >1500 g. The feeds were increased at a rate of 30 ml/kg/day for ≥1500 g and 20 ml/kg/day for those <1500 g, if baby has no intolerance to initial feeds. We used mother's own milk (MOM), and if it was not available, then pasteurized donor human milk (PDHM) from institute's milk bank was used for the period till MOM was available. We did not use any kind of infant formula in our unit. We did not aspirate the gastric residuals routinely unless there was increase in abdominal girth of ≥2 cm from base line. Abdominal girth was monitored before every feed. The infants who required total parenteral nutrition (TPN) were started proteins at 2 g/kg/day and lipids at 1 g/kg/day on day 1, keeping the protein:calorie ratio of 25–40 by adjusting the glucose infusion rate (GIR). We added human milk fortifier (HMF) in VLBW infants, if the infant does not gain weight of ≥15 g/kg/day at a feed volume of ≥180 ml/kg/day. If the infant had repeated vomiting or gastric residuals of ≥50% of previous feed volume and hemodynamically unstable, the feeds were restricted to trophic feeds only. We discharged the infants on feeds of ≥150 ml/kg/day, when they gain adequate weight for ≥3 consecutive days and were hemodynamically stable. SGA was defined as ≤-1.28SD (≤10th percentile). The extra-uterine growth restriction (EUGR) status of infants was assessed by using a criteria of ≤-1.28SD (≤10th percentile) at discharge. Approval from institutional ethical committee was obtained prior to study. As this is a retrospective study, the consent from parents was not required.

Statistics

All the infants born and admitted in our hospital from January to December 2019 were considered for the study. A convenient sample size was considered over a period of one year. A total of 118 infants were eligible for study based on inclusion criteria. Continuous variables are represented as mean with standard deviation. Chi-square test is applied for categorical variable. Agreement statistics is done by Cohen's kappa test.

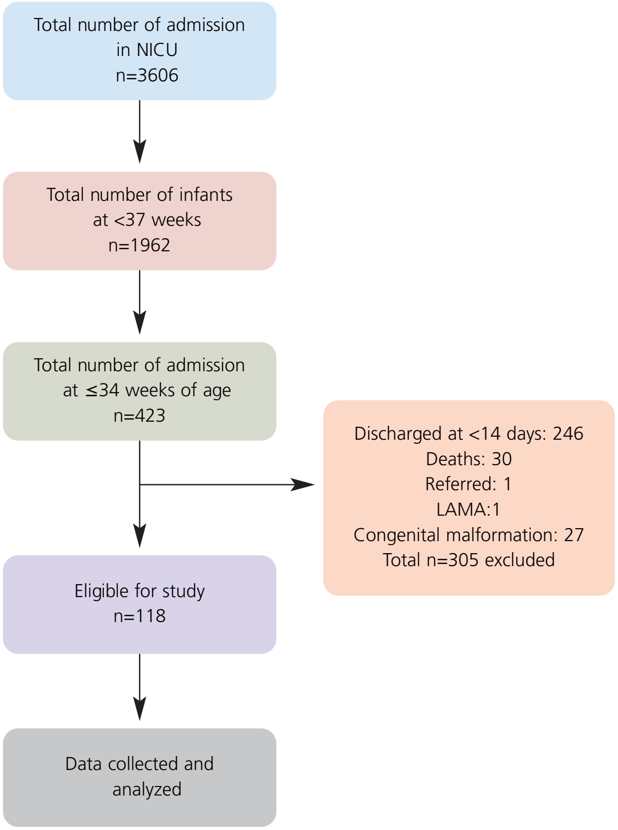

Fig. 1. Flow chart depicting the study.

Statistical analysis is done by using SPSS version 22 (IBM Inc., Armonk, NY, USA).

Results

A total of 423 babies were born and admitted during study period. Among them, 118 babies required to stay beyond 14 days in hospital, which constituted our study population and whose details have been collected for analysis. Mean gestational age was 31.6 weeks. Spontaneous onset of labor pain (47.4%) and preterm premature of rupture of membranes (24.5%) were found to be the common reason for preterm delivery. Majority of the babies (n=93, 78.8%) out of 118 babies were born out of singleton pregnancy. The mean birth weight was 1608±275 g. The babies required around 10.4 days to reach 150 ml/kg/day of feeds and the mean duration of hospital stay was 24.8 days (**Table 1**). The mean gestational age at discharge was 35.4 weeks and mean weight at discharge was 1730±226 g.

Table 1. Maternal and neonatal characteristics.

Variables	n=118 (%)	
Maternal age (mean±SD), years	24.9±4.14	
Obstetric index	Primi	71 (60.17%)
	Multi	47 (39.8%)
GA (mean±SD), weeks	31.6±1.42	
GA assessed by	Early scan	92.30%
	Others	7.70%
GHT	36 (30.5%)	
GDM	2 (1.69%)	
PPROM	29 (24.5%)	
Hypothyroidism	7 (5.9%)	
Oligohydramnios	12 (10.1%)	
Polyhydramnios	1 (0.85%)	
ACS	104 (88.1%)	
MOD	Vaginal	73 (61.8%)
	LSCS	45 (38.1%)
Preterm phenotype	Spontaneous	56 (47.4%)
	pPROM	29 (24.5%)
	Indicated	33 (28.2%)
Risk of EOS	24 (20.3%)	
Maternal weight (mean±SD), kg	58.6±12.3	
Neonatal sex distribution	Male	60 (50.8%)
	Female	58 (49.1%)
Gestational age at birth (mean±SD), weeks	31.6±1.42	
Birth weight (mean±SD), g	1608.06±275	
Singleton	93 (78.9%)	
TTR (150 ml/kg/d) (mean±SD), days	10.4±2.77	
Duration of stay (mean±SD), days	24.8±9.6	
Gestation at discharge (mean±SD), weeks	35.4±1.47	
Weight at discharge (mean±SD), g	1732±226.3	
RDS	27 (22.8%)	
Respiratory support	72 (61.01%)	
Antibiotics (sepsis)	87 (73.7%)	
Inotropes	25 (21.1%)	

ACS: antenatal corticosteroids; **EOS:** early onset sepsis; **GA:** gestational age; **GDM:** gestational diabetes mellitus; **GHT:** gestational hypertension; **MOD:** mode of delivery; **pPROM:** preterm premature rupture of membrane; **RDS:** respiratory distress syndrome; **TTR:** time to reach full feeds.

The numbers of infants with SGA at birth using birth weight as criteria were 18 (15.2%) and 16 (13.5%) with Intergrowth-21st and Fenton growth charts, respectively. The number of large for gestational age (LGA) babies was 5 (4.2%) using both growth charts. Only 6% of infants identified as SGA at birth by Fenton were labelled appropriate for gestational age (AGA) by Intergrowth-21st charts. Similarly, 16% of SGA infants by Intergrowth-21st charts were labelled AGA by Fenton. Overall, the identification of birth size had some difference between growth charts.

Table 2. Distribution of infants' growth at birth and EUGR rate at discharge (n, %).

Weight classification at birth	IG-21st	Fenton
AGA	95 (80.5%)	97 (82.2%)
SGA	18 (15.2%)	16 (13.5%)
LGA	5 (4.2%)	5 (4.2%)
EUGR at discharge	86 (72.8%)	96 (81.3%)

$p=0.07$ at birth (not significant at <0.05). $p=0.09$ at discharge (EUGR) (not significant at <0.05). **AGA:** appropriate for gestational age; **EUGR:** extrauterine growth restriction; **IG-21st:** Intergrowth-21st; **LGA:** large for gestational age; **SGA:** small for gestational age.

The EUGR component using ≤-1.28SD was present in 86 (72.8%) and 96 (81.3%) babies using Intergrowth-21st and Fenton growth charts, respectively (**Table 2**). Among the EUGR infants identified by Fenton charts, 8.5% of these infants were considered AGA at discharge by Intergrowth-21st charts. The rates of EUGR infants identified by Fenton charts were higher compared to Intergrowth-21st growth charts.

Discussion

The growth of preterm babies following premature birth is a challenge to the caregiver. These premature infants would go through many complications postnatally which hamper their postnatal nutrition and has many complications in the short- and long-term.[7] Thus, it becomes important to keep watch on nutrition and growth of these premature infants. To keep a watch on growth, we need a growth chart which could define the appropriate growth for premature infants.

Fenton growth charts are the one which are commonly used by many NICUs for monitoring growth. Of late, Intergrowth 21st growth charts have been published which are supposed to be better as they are prescriptive standards for preterm and term infants. In this study, we aimed to compare Fenton and Intergrowth-21st growth charts in assessing the growth at birth and at discharge to find the difference between these two growth charts.

In a prospective study on 248 premature infants less than 32 weeks of gestational age conducted by Tuzun et al.,[11] the authors found that the SGA rate was significantly higher and the EUGR rate was significantly lower with the Intergrowth-21st charts compared with Fenton growth chart. In our study, the rate of SGA babies identified at birth was slightly higher and the rate of EUGR babies was slightly lower in Intergrowth-21st chart compared to Fenton growth chart which was similar to the study conducted by Tuzun et al. The difference of IUGR and EUGR in Tuzun et al.'s study had a statistical significance, which in our study, we could not find a significant difference on statistical analysis. The reasons could be because of the infant characteristics in the study of Tuzun et al., and also the rate of maternal complications were high in their study, which could cause IUGR, and also had infants who required intensive care at birth compared to the infants in our study which could cause EUGR in those infants. In our study, we had a higher number of infants born by spontaneous onset of labor pains without any other cause for prematurity, and our infants required intensive care for a short period of time.

In a retrospective study conducted by Reddy et al.[12] on 603 premature infants born at <32 weeks of gestation, the authors found that the rate of infants identified as IUGR at birth with respect to weight by Intergrowth-21st chart was higher and also EUGR rate was higher compared to Fenton growth chart. They also found that the incidence of morbidities in IUGR infants identified by Intergrowth-21st charts was higher. In our study, we had similar results as described in Reddy at al.'s study in terms of identifying IUGR at birth by both charts. This difference could be because of difference in inclusion criteria in our study, which included only those babies who survived till discharge, and also the predominant infant population in our study were between 30 and 34 weeks of gestation, which are expected to have few comorbidities. These differences could have changed the results of morbidity profile in our study.

In a study conducted by Yitayew et al.[13] in infants born between 24–33 weeks of gestation, the authors also found that the SGA rate identified by Intergrowth-21st was high but not significant, and the EUGR rate identified was low when compared to Fenton growth charts which was found to be statistically significant. These results were similar to our study except for the statistical significance.

In a study conducted on 318 preterm infants born at <37 weeks of gestation, Patel et al.[14] found that there is poor agreement between the both the growth charts in identifying weight, length and head circumference at birth. Similar to this study, there is also poor agreement between the growth charts after applying Cohen's kappa test for agreement among growth charts in our study.

Even though the proportion of SGA at birth was slightly higher in Intergrowth-21st chart compared to Fenton chart, we did not find a statistically significant difference in identifying the SGA at birth after performing a chi square analysis (chi-square 2.86, p=0.09).

In our study, we defined EUGR ≤-1.28SD.[10] The rate of EUGR was higher in Fenton charts compared to Intergowth-21st charts, but there was statistically no significant difference in EUGR rates identified by both growth charts after applying chi square test (p=0.09).

The studies conducted by Tuzun et al.,[11] Reddy et al.,[12] Yitayew et al.[13] and Patel et al.[14] found that there was significant difference in identifying the EUGR rates by both growth charts, contrary to our study, in which we found no statistical difference. The reason for this contradiction could be due to the difference in sample size used, feeding strategy in our unit, which follows a restricted feeding during the period of illness and also we had a higher number of mature infants compared to other studies.

This study has some limitations. We did not include the head circumference and length at birth and at discharge in defining IUGR and EUGR which could have added more insight into the growth of infants in comparing the Intergrowth-21st and Fenton growth charts.

Conclusion

Our study showed that there is no difference in identifying AGA and SGA at birth when using Intergrowth-21st and Fenton growth charts. The rate of EUGR identified by Intergrowth-21st chart was comparatively less than Fenton charts. Large scale prospective studies should be conducted to compare these growth charts before implementing Intergrowth-21st charts universally as standards for assessing size at birth and also at discharge.

Funding: This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Compliance with Ethical Standards: The authors stated that the standards regarding research and publication ethics, the Personal Data Protection Law and the copyright regulations applicable to intellectual and artistic works are complied with and there is no conflict of interest.

References

1. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet 2016;388(10063): 3027–35. [PubMed] [CrossRef]
2. Horbar JD, Ehrenkranz RA, Badger GJ, Edwards EM, Morrow KA, Soll RF, et al. Weight growth velocity and postnatal growth failure in infants 501 to 1500 grams: 2000–2013. Pediatrics 2015;136:e84–e92. [PubMed] [CrossRef]
3. Fenton TR, Kim JH. A systematic review and meta-analysis to revise the Fenton growth charts for preterm infants. BMC Pediatr 2013;13:59. [PubMed] [CrossRef]
4. WHO Multicentre Growth Reference Study Group. WHO child growth standards: length/height-for age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. Geneva: World Health Organization; 2006.
5. Villar J, Giuliani F, Fenton TR, Ohuma EO, Ismail LC, Kennedy SH; INTERGROWTH-21st Consortium. INTERGROWTH 21st very preterm size at birth reference charts. Lancet 2019;387:844–5. [PubMed] [CrossRef]
6. Villar J, Giuliani F, Bhutta ZA, Bertino E, Ohuma EO, Ismail L, et al.; International Fetal and Newborn Growth Consortium for the 21(st) Century (INTERGROWTH-21(st)). Postnatal growth standards for preterm infants: The preterm postnatal follow-up study of the INTERGROWTH-21st project. Lancet Global Health 2015;3:e681–91. [PubMed] [CrossRef]
7. Senterre T, Rigo J. Optimizing early nutritional support based on recent recommendations in VLBW infants and postnatal growth restriction. J Pediatr Gastroenterol Nutr 2011;53:536–42. [PubMed] [CrossRef]
8. Pereira-da-Silva L, Virella D. Is intra-uterine growth appropriate to monitor postnatal growth of preterm neonates? BMC Pediatrics 2014;14:14. [PubMed] [CrossRef]
9. Lima PAT, de Carvalho M, daCosta ACC, Moreira MEL. Variables associated with extrauterine growth restriction in very low birth weight infants. J Pediatr (Rio J) 2014;90:22–7. [PubMed] [CrossRef]
10. Ehrenkranz RA. Extra-uterine growth restriction: is it preventable? J Pediatr (Rio J) 2010;90:1–3. [PubMed] [CrossRef]
11. Tuzun, F, Yucesoy, E, Baysal, B, Kumral, A, Duman, N, Ozkan, H. Comparison of INTERGROWTH-21 and Fenton growth standards to assess size at birth and extrauterine growth in very preterm infants. J Matern Fetal Neonatal Med 2018;31:2252–7. [PubMed] [CrossRef]
12. Reddy KV, Sharma, D, Vardhelli V, Bashir T, Deshbotla SK, Murki S. Comparison of Fenton 2013 growth curves and Intergrowth-21 growth standards to assess the incidence of intrauterine growth restriction and extrauterine growth restriction in preterm neonates ≤32 weeks. J Matern Fetal Neonatal Med 2021;34:2634–41. [PubMed] [CrossRef]
13. Yitayew M, Chahin N, Rustom S, Thacker LR, Hendricks-Munoz KD. Fenton vs Intergrowth-21st: postnatal growth assessment and prediction of neurodevelopment in preterm infants. Nutrients 2021;13:2841. [PubMed] [CrossRef]
14. Patel DV, Upadhyay V, Phatak AG, Thakker B, Nimbalkar SM. Comparison of Fenton versus Intergrowth-21 growth charts for preterm neonates. Journal of Neonatology 2021;35: 131–7. [CrossRef]