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Comparison between INTERGROWTH-21ST and Fenton charts for extrauterine growth in very low birth weigth infants

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Abstract

Background The growth of premature infants is expected to be equivalent to healthy fetal growth, but this is rarely achieved in practice. It is predicted that many premature infants, especially severe premature infants, will be discharged with growth restriction. Extrauterine growth retardation (EUGR) is defined as growth below the 10th percentile of the growth curve at discharge at corrected 36th/40th week of gestation, or a difference between birth and discharge z-score > 1 SD. The aim of our study is to determine the differences between the INTERGROWTH-21ST and the Fenton chart in the assessment of extrauterine growth.

Methods Infants < 1500 g born or transferred in the first 24 h at Ankara University NICU between January 1, 2015 and December 31, 2019 were included. Infants with major congenital anomalies, unknown gestational age, chromosomal anomalies, hydrops fetalis, TORCH infection, infants born to substance abusing mothers, and infants who died during hospitalization were excluded.

Results According to the Fenton, the rate of EUGR at discharge was 66.3%. There was no significant difference between the groups EUGR and non-EUGR in gender, gestational diabetes, maternal smoking during pregnancy, placental abruption, magnesium sulphate prophylaxis, development of respiratory distress, and need for intubation in the first 3 days after birth. When patients were grouped according to birth weight, the highest rate of EUGR according to the Fenton was found in the group with a birth weight ≤ 1000 g (78.8%) ($p = 0.036$). The proportion of patients defined as SGA by INTERGROWTH-21ST was significantly higher than by Fenton ($p < 0.001$). Comparing the mean z scores for body weight, height and head circumference at birth and discharge calculated from the Fenton and INTERGROWTH-21 charts, the z scores for body weight and height at birth and discharge were significantly lower in the INTERGROWTH-21 ($p < 0.001$). Head circumference z-scores at birth and discharge were found to be higher in the Fenton chart than in the INTERGROWTH-21ST ($p < 0.001$). When EUGR rates were evaluated by body weight in Fenton and INTERGROWTH-21ST, the EUGR rate was found to be higher in Fenton ($p < 0.001$).

Conclusions The results show that when INTERGROWTH-21ST and Fenton are compared, INTERGROWTH-21ST is more sensitive in defining the SGA rate. The Fenton is more sensitive in defining EUGR at discharge. These differences between the charts make it difficult to monitor the growth of premature infants and to follow comorbidities.

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Therefore, the establishment of ideal growth curves is of great importance both during hospitalization and after discharge of premature infants.

Keywords Extrauterin growth retardation, Fenton chart, INTERGROWTH-21ST, Small for gestational age

Introduction

The evolution of neonatal care over the past few decades has resulted in an increased chance of survival for premature infants with smaller gestational age. Many very low birth weight (VLBW) premature infants spend as long as the third trimester in the neonatal intensive care unit (NICU). The idea that the growth of premature infants in the NICU should be the same as that of healthy fetuses has not been supported by data, and it is predicted that most extremely premature infants will be discharged with growth restriction [1]. It is important to closely monitor the growth of preterm infants during their stay in the NICU. The growth charts used for monitoring are universal and independent of time and place. Therefore, they are not intended to represent a specific population or region and can be used to evaluate all fetuses and infants regardless of their socioeconomic status and level of access to health care [2]. The Lubchenco, Usher, Babson, and Benda charts, which have been used for intrauterine growth since the 1960s, were updated after the 1990s on the basis of Babson and Benda, and the Fenton charts, which are the most widely used today, were created [3, 4]. In addition, the INTERGROWTH-21ST (IG-21) project was established by the International Fetal and Newborn Consortium to evaluate growth between pregnancy and early infancy. A multicenter, multiethnic, population-based study was created in 2013 that proposed growth patterns with a representative population sample from eight geographic regions of the World Health Organization (WHO). Most of the women, who were followed up before the 14th week of gestation, had their health and nutritional needs met and were not exposed to environmental agents during pregnancy. IG-21 postnatal growth of preterm infants is the growth chart formed from the data obtained as a result of the cohort formed by standardized measurements of individual preterm infants born to the participants at 26 to 37 weeks of gestation [5].

The aim of this study was to determine the extrauterine growth rates of VLBW infants followed in the NICU and to compare the Fenton, which is widely used in our country and in many other countries, with the IG-21.

Methods

Infants with birth weight ≤ 1500 g who were born or transferred to the NICU of Ankara University School of Medicine in the first 24 h postnatally between January 1, 2015 and December 31, 2019 and could be discharged from the unit were included. Infants with major congenital anomalies (congenital heart disease other than patent ductus arteriosus, cleft palate/lip, syndromes, etc.), unknown gestational age (last menstrual period of the mother is unknown), chromosomal abnormalities, hydrops fetalis, TORCH infection, infants born to substance abusing mothers and those who died during hospitalization were excluded. Demographic data and anthropometric measurements of the infants were recorded at 24 h, 96 h, 7-14-21-28 days postnatally and at discharge. Percentiles and z-scores of all patients' anthropometric measurements were evaluated electronically using the Fenton 2013 growth chart. Birth anthropometric measurements were evaluated using the Newborn Size for Very Preterm Infants chart and follow-up and discharge measurements were evaluated using the Postnatal of Preterm Infants chart [5, 6]. (https://intergrowth21.tghn.org/standards-tools/). In our study, extrauterine growth retardation was defined as body weight < 10th percentile at discharge and change in weight z-score at discharge as > 1 SD.

Statistics

The SPSS 22 program was used to analyze the data. All variables determined by measurement are presented as descriptors by checking the distribution (mean ± SD, minimum, maximum and median) and prevalence criteria. The percentage distributions of categorical and ordinal variables are reported. Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine whether or not the variables followed a normal distribution. For independent continuous variables with normal distribution, the mean of the groups was compared with the t-test, and if the normal distribution was disturbed, the nonparametric equivalent of the t-test was compared with the Mann-Whitney U test, and the distributions of the two independent groups were compared. When comparing dependent groups for continuous variables, the dependent groups t-test was used. In univariate analyses, the effect of categorical independent variables on the dependent variable was performed by chi-squared analysis, and the comparison of ratios of dependent variables was performed by McNemar test. The *p*-value, which is the limit of significance, was accepted as 0.05 in all tests.

Results

One hundred and eighty-one patients who met the inclusion criteria and whose nutritional records were fully accessible from the archive were enrolled in the study. The mean gestational age of the patients included in the study was 30 ± 2.3 weeks, and the median was 29 weeks

Table 1 Prenatal and Natal characteristics of preterm infants enrolled in the study

Characteristics	Frequency (*n*)	Percent (%)
Preeclampsia/Eclampsia	50	27,6
Gestational Diabetes Mellitus	7	3,9
Smoking During Pregnancy	14	7,7
Ablatio Placentae	4	2,2
Prolonged Rupture of Membranes	34	18,8
Chorioamnionitis	21	11,6
Antenatal Steroid		
Completed	110	60,8
Single Dose	24	13,3
Not Applied	47	25,9
Magnesium Sulphate Prophylaxis	19	10,5
Gender		
Girl	82	45,3
Boy	99	54,7
Number of Babies		
Single	123	68
Multiple	58	32
Birth Type		
C/S	158	87,3
Vaginal	23	12,7
Need for Resuscitation		
Yes	50	27,6
Positive Pressure Ventilation	32	17,6
Cardiopulmonary Resuscitation	18	10
No	131	72,4

C/S: caesarean section

Table 2 Evaluation of birth and discharge anthropometric measurements by Fenton and the INTERGROWTH-21ST charts

FENTON		Mean ± Std.	Min	Max
Birth	**Weight Percentile**	31,5 ± 27,9	0	100
	Weight z-score	-0,66 ± 1,05	-3,01	3,51
	Length Percentile	28,6 ± 28,3	0	98
	Length z-score	-0,84 ± 1,06	-3,55	2,11
	Head Circumference Percentile	32,3 ± 26,4	0	96
	Head Circumference z-score	-0,64 ± 0,98	-3,18	1,71
Discharge	**Weight Percentile**	10,1 ± 12,7	0	55
	Weight z-score	-1,8 ± 1,14	-6,56	0,8
	Length Percentile	11,3 ± 14,6	0	71
	Length z-score	-1,7 ± 1,01	-5,08	0,55
	Head Circumference Percentile	14,4 ± 15,8	0	77
	Head Circumference z-score	-1,41 ± 0,93	-5,34	0,75
INTERGROWTH-21ST				
Birth	**Weight Percentile**	49,9 ± 36,3	0,04	99,91
	Weight z-Score	-0,17 ± 1,58	-3,35	3,11
	Length Percentile	40,5 ± 34,4	0	99,8
	Length z-score	-0,52 ± 1,49	-4,64	3,04
	Head Circumference Percentile	26,3 ± 25,4	0	93,52
	Head Circumference z-Score	-0,95 ± 1,08	-4,05	1,51
Discharge	**Weight Percentile**	18,4 ± 24	0	96,33
	Weight z-score	-1,55 ± 1,39	-6,46	1,79
	Length Percentile	14,7 ± 21,2	0	92,99
	Length z-score	-1,81 ± 1,43	-6,15	1,47
	Head Circumference Percentile	11,3 ± 16,8	0	84,16
	Head Circumference z-score	-1,85 ± 1,24	-6,62	1

($24^2/7$–$35^2/7$ weeks). The natal and prenatal characteristics of the patients are presented in Table 1.

Patients were grouped by birth weight, there were 52 patients (28.7%) under 1000 g, 56 patients (30.9%) 1001–1250 g and 73 patients (40.3%) 1251–1500 g. When the patients were grouped according to gestational weeks, there were 39 patients (21.5%) born at 24–27 weeks of gestation, 57 patients (31.5%) at 28–29 weeks of gestation, 44 patients (34.3%) at 30–31 weeks of gestation, and 41 patients (22.7%) born after 32 weeks of gestation. The mean birth weight of the patients was 1160 ± 235 g. The lowest birth weight was 450 g at 24^2 weeks gestation. Mean birth length and head circumference were 36.8/26.3 cm. The mean percentiles and z-scores of the patients' anthropometric measurements at birth and discharge by Fenton and IG-21 charts are presented in Table 2.

Measurements showed that the rate of small for gestational age (SGA) increased with gestational week, and the highest SGA rate was found at ≥ 32 weeks of gestation. When patients were grouped by birth weight, there was no difference between groups and SGA rates were homogeneously distributed. The EUGR rate increased with increasing weeks of gestation, and the highest EUGR rate was in the ≥ 32 weeks group ($p < 0.001$). When patients were grouped according to birth weight, the highest EUGR rate according to Fenton was in the group with a birth weight below ≤ 1000 g (%78.8) (p: 0.036).

According to Fenton, there were 120 (66.3%) patients with extrauterine growth retardation (EUGR) and 61 (33.7%) patients non-EUGR at discharge. There was no significant difference between the EUGR and non-EUGR groups in terms of gender, gestational diabetes mellitus (GDM), maternal smoking during pregnancy, placental abruption, magnesium sulphate prophylaxis, development of respiratory distress syndrome (RDS), and need for intubation in the first 3 days after birth. The rates of antibiotic use in the first 3 postnatal days and the need for resuscitation at birth were higher in the group non-EUGR. Although the rates of mothers with prolonged rupture of membranes and chorioamnionitis in pregnancy were higher in the group non-EUGR at discharge, the rate of eclampsia/preeclampsia at discharge was higher in the group with EUGR (Table 3).

Table 3 Evaluation of prenatal, Natal and postnatal characteristics with EUGR according to Fenton charts

		EUGR (+) (*n* = 120)	EUGR (-) (*n* = 61)	Total (*n* = 181)	*p* Value
Prenatal					
Gender	Girl	54 (%45)	28 (%45,9)	82 (%45,3)	0.908
	Boy	66 (%55)	33 (%54,1)	99 (%54,7)	
Preeclampsia/Eclampsia		45 (%37,5)	5 (%8,2)	50 (%27,6)	**< 0.001**
Gestational diabetes mellitus		7 (%5,8)	0 (%0)	7 (%3,9)	0.120
Smoking		11 (%9,2)	3 (%4,9)	14 (%7,7)	0.389
Ablatio Placentae		2 (%1,7)	2 (%3,3)	4 (%2,2)	0.604
Prolonged Rupture of Membranes		14 (%11,7)	20 (%32,8)	34 (%18,8)	**0.001**
Chorioamnionitis		7 (%5,8)	14 (%23)	21 (%11,6)	**0.002**
Magnesium Sulphate Prophylaxis		11 (%9,2)	8 (%13,1)	19 (%10,5)	0.413
Small for gestational age		58 (%48,3)	0 (%0)	58 (%32)	**< 0.001**
Natal					
Birth Type	Vaginal	8 (%6,7)	15 (%24,6)	23 (%12,7)	**0.001**
	C/S	112 (%93,3)	46 (%75,4)	158 (%87,3)	
Resuscitation		27 (%22,5)	23 (%37,7)	50 (%27,6)	**0.031**
Postnatal					
Respiratory distress syndrome		31 (%25,8)	20 (%32,8)	51 (%28,2)	0.326
Intubation*		27 (%22,5)	16 (%26,2)	43 (%23,8)	0.577
Use of Antibiotics*		57 (%47,5)	54 (%88,5)	111 (%61,3)	**< 0.001**

* In the first 3 postnatal days

C/S: caesarean section

Table 4 Comparison of EUGR and Enteral-Parenteral nutritional parameters

	EUGR (+) (*n* = 120)		EUGR (-) (*n* = 61)		*p* Value
	Mean (Day)	Std.	Mean (Day)	Std.	
MEN Starting	1,6	0,8	1,7	0,9	0.199
TPN Starting	1,2	0,5	1,3	0,5	0.647
Duration of TPN	12,8	11	10	5,6	**0.050**
Duration of IV Lipid	9,8	8,8	7,1	5	**0.028**
Time to Birth Weight	10,9	4,6	12,3	4,5	**0.030**
100 ml/kg/day Time to Enteral Access	12,4	8	9,7	5,1	**0.018**
Transition to Full Enteral Nutrition	16,1	11,3	13,5	7,2	0.096
Hospitalization Duration	38,7	23,3	40,8	15,5	0.529

MEN: Minimal Enteral Nutrition, TPN: Total Parenteral Nutrition

The time to receive TPN, IV lipid solution, and 100 ml/kg/day enteral nutrition in the NICU was significantly longer in patients with EUGR compared to those with non-EUGR. The time to reach birth weight was longer in infants with non-EUGR compared to infants with EUGR (Table 4).

Weekly weight gain was calculated as g/kg/day for postnatal 96 h and 4 weeks based on EUGR definition at discharge according to the Fenton curve. It was observed that the weight loss of the non-EUGR infants was significantly higher at postnatal 96 h and at the end of the first week, and the weekly weight gain was significantly higher at postnatal week 4 ($p < 0.001$) (Fig. 1). The cumulative amino acid intake of the infants on TPN during postnatal 24 h, 96 h, and the first 4 weeks was calculated as g/kg/day. No difference was found between the weekly amino acid intakes of the two groups (Fig. 2).

It was found that the rate of EUGR increased with increasing gestational week, and the highest rate of EUGR was found in the 32-week group. When the infants were grouped according to birth weight, it was found that the Fenton EUGR rate was highest in the group with a birth weight less than ≤ 1000 g (78.8%). All infants who were Fenton SGA at birth had Fenton EUGR at discharge. When the differences between the discharge z-score and the birth z-score according to Fenton were evaluated for body weight, height, and head circumference in patients with EUGR and non-EUGR, the difference in z-score for body weight only was negative in patients with EUGR. There was no significant difference between the z-score changes in height and head circumference for both groups (Table 5).

Comparing IG-21 and Fenton weight for gestational age and EUGR rates, the proportion of patients defined as SGA and EUGR by IG-21 was significantly higher than by Fenton. Of the 68 patients defined as SGA by the IG-21, only 57 were SGA by the Fenton, and 11 of the 113 patients defined as AGA by the Fenton were defined as SGA by the IG-21. The rate of EUGR at discharge was also lower with IG-21; 15 of 120 patients defined as EUGR by Fenton were not classified as EUGR by IG-21. All 105 patients identified as EUGR by IG-21 are also EUGR by Fenton.

When the mean z-scores of the patients at birth and at discharge (calculated according to the Fenton and IG-21 of body weight, length and head circumference) were compared, it was found that the z-scores of body weight and length at birth and at discharge were significantly lower than IG-21. The z-score for head circumference, on the other hand, had higher values in the Fenton at birth and discharge than in the IG-21 (Table 6).

When the weight z-scores for boys and girls were evaluated according to the Fenton and IG-21 charts based on weeks of gestation, it was observed that the IG-21 z-score

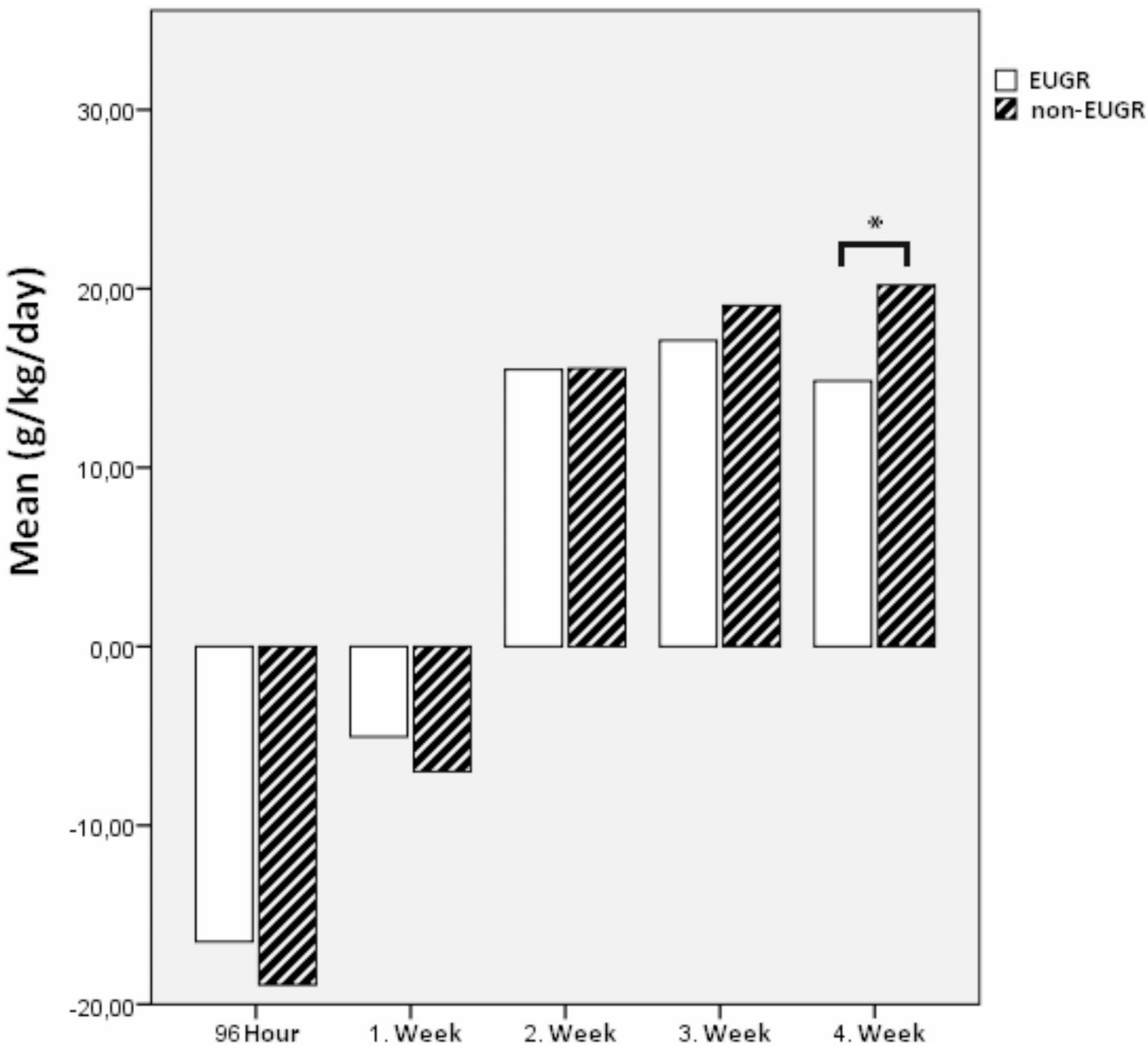

Fig. 1 Comparison of Body Weight Change by Weeks

values for both sexes were higher up to 31 weeks of gestation. From the 31st week of gestation until the corrected age reaches the 37th week of gestation, the curves overlap and there is no difference between them. For boys, the mean height z-score was higher compared to the IG-21 up to the corrected 31st week of gestation, and the mean z-score obtained from the Fenton was found to be higher at 35–37 weeks of gestation. For girls, the mean height z-score was corrected according to the IG-21 and was higher until 32 weeks of gestation, and no difference was observed between the following weeks. Although the average mean z-score of Fenton head circumference for boys was higher after the corrected 31st week of gestation, there was no difference in the following weeks. The mean z-score of Fenton's head circumference in girls was high between 31 and 32 weeks of gestation and between 33 and 34 weeks of gestation, and no difference was found in other weeks (Fig. 3).

Discussion

In our study evaluating the growth of infants with birth weight ≤ 1500 g during neonatal intensive care, we found that 66.3% ($n = 120$) of our patients had EUGR at discharge according to Fenton. In our cohort with an SGA rate of 32% ($n = 58$), the parameters associated with EUGR were low birth weight, advanced gestational age, and prolonged time to birth weight. The percentage of patients identified as SGA by IG-21 was significantly higher than by Fenton. When the mean z-scores of anthropometric measurements at birth and discharge

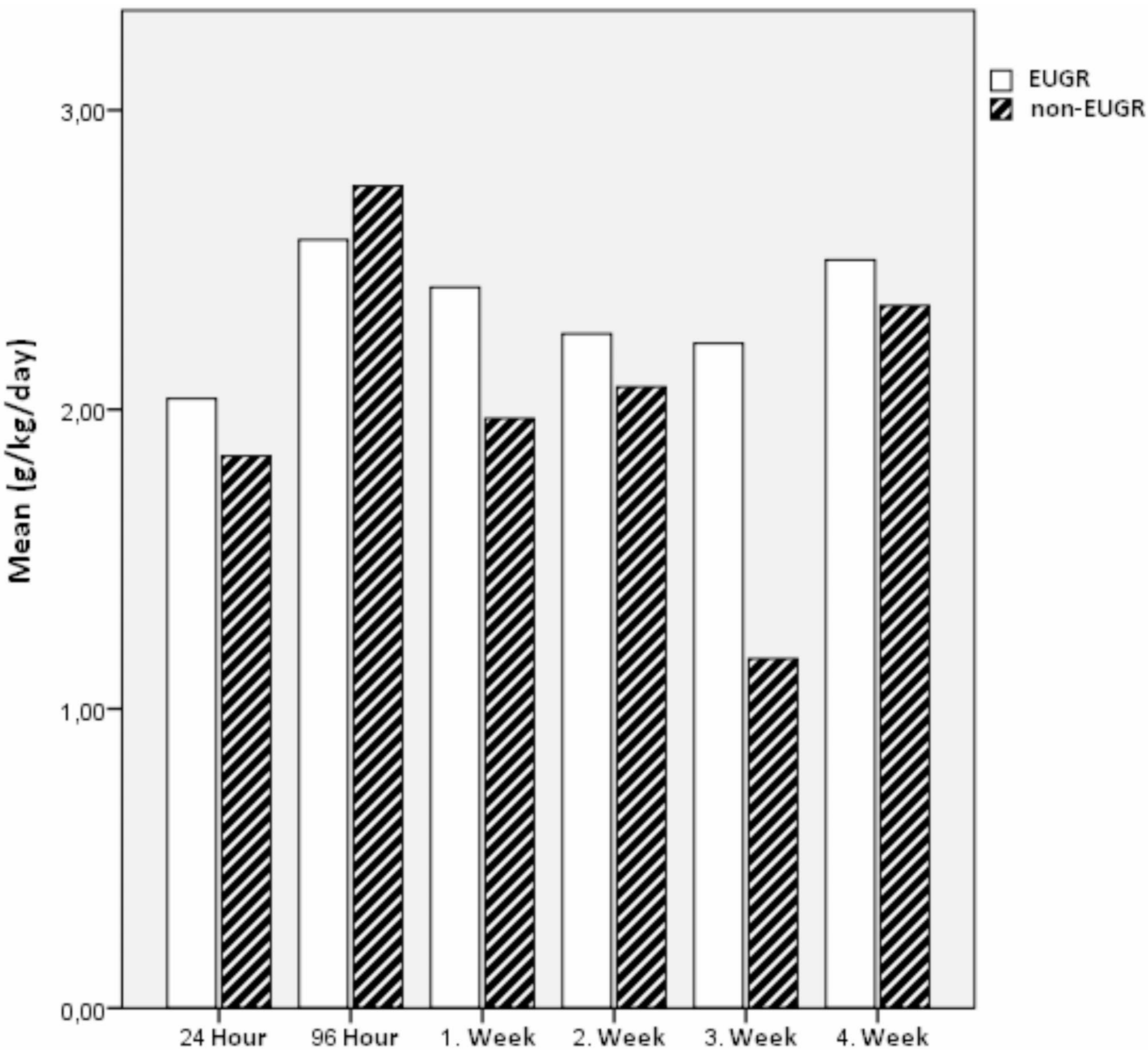

Fig. 2 Comparison of TPN Amino Acid Concentration According to Weeks

Table 5 Comparison of EUGR and z-score changes of anthropometric measurements

	EUGR (+)		EUGR (-)		*p* value
	Mean	Std.	Mean	Std.	
Weight	-1,26	0,76	-0,90	0,54	**0.001**
Length	-0,90	0,70	-0,89	0,55	0.625
Head Circumference	-0,74	0,74	-0,85	0,66	0.290

Table 6 Comparison of birth and discharge anthropometric measurement z-scores according to Fenton and IG-21 charts

BIRTH	INTERGROWTH-21ST		FENTON		*P* Value
	Mean	Std.	Mean	Std.	
Weight	-0,17	1,58	-0,74	0,99	< 0,001
Length	-0,52	1,49	-0,90	1,06	< 0,001
Head Circumference	-0,95	1,08	-0,68	0,98	< 0,001
DISCHARGE					
Weight	-1,55	1,39	-1,80	1,14	< 0,001
Length	-1,81	1,43	-1,70	1,01	< 0,001
Head Circumference	-1,85	1,24	-1,41	0,93	< 0,001

were compared according to the Fenton and IG-21, the mean z-score of the IG-21 was significantly higher for body weight and height. However, according to the IG-21, the head circumference percentile and z-score at birth and discharge are lower.

The head circumference z-score was found to have higher values in the Fenton at birth and at discharge

Fig. 3 Comparison of Z-Scores According to Fenton and INTERGROWTH-21ST Charts According to Gestational Week

compared to the IG-21. We have shown that the graphical divergence between the two growth charts begins around 31 weeks of gestation.

Existing EUGR definitions can be classified into two groups: cross-sectional, which includes weight below the 10th percentile (or other cut-off) at a given time, regardless of birth weight, and longitudinal, which includes weight loss of more than 1 (or 2) standard deviations (SD) between birth and a given time. Three specific time points have been suggested in the literature: 36 weeks of gestation, discharge from hospital, and 28 days of postnatal age [7]. Choosing the right cut-off to define EUGR in longitudinal assessment is important because the lower the birth weight percentile, the lower the probability of losing 1 or 2 SDs. For this reason, and considering the large number of SGA in our NICU, we chose a weight loss of 1 SD as the cut-off for longitudinal assessment.

The NICHD Neonatal Research Network reported the incidence of EUGR to be 79% in 9575 premature infants between 22 and 28 weeks of gestation. The incidence varied from 59 to 97% among the centers participating in the study [8]. An incidence study conducted in North America between 2000 and 2013 included 390,801 preterm infants and found that the rate of EUGR at discharge decreased from 39.8 to 27.5% over the years, and extremely low birth weight (ELBW) preterm infants were found to be the group with the highest incidence of EUGR [8]. Not only does the incidence of EUGR vary on a population basis, but there are also definitional differences between studies [9].

When all infants included in the study were evaluated, the incidence of EUGR was 66.3% ($n = 120/181$) and the group with the highest EUGR was infants with a birth weight of ≤1000 g (78.8%). When we evaluated the SGA ratios according to the Fenton charts, we found that 43.1% ($n = 25$) of all SGA infants weighed 1251–1500 g. All infants with SGA had EUGR at discharge. This result, consistent with the literature, showed that SGA was an important risk factor for EUGR in our cohort [10–12].

When we evaluated the prenatal, natal, and postnatal characteristics of infants with and without EUGR, we found that prolonged rupture of membranes, chorioamnionitis, need for resuscitation at birth, and use of antibiotics in the first 3 days postnatally were higher in the group without EUGR. Compared to the results of the present study regarding the higher percentages of EUGR in those born from PROM, with resuscitation at birth or antibiotic treatment, it is possible to hypothesize that prenatal conditions (such as preeclampsia or eclampsia) that act chronically and for prolonged periods of time may have significantly influenced the derailment of endocrine-metabolic programming, as demonstrated by many studies conducted to date in the field of epigenetics [13, 14]. Eclampsia/preeclampsia was found at a higher rate in the group with EUGR and can be indirectly defined as a risk factor for EUGR. Eclampsia/preeclampsia was found at a higher rate in the EUGR group and can be indirectly defined as a risk factor for EUGR by causing IUGR [10, 12, 15, 16].

Birth weight, head circumference, and length percentile and z-score were calculated according to IG-21 newborn size for very preterm infants. In a retrospective study in which anthropometric measurements of 693 preterm infants less than 32 weeks gestation were evaluated according to Fenton and IG-21, it was shown that up to 3% of infants with AGA according to Fenton were SGA according to IG-21 [17]. In a cohort of 45,505 infants born at 33–40 weeks gestation, IG-21 defined 2–3 times more SGA infants than Fenton charts [18]. In our study, the number of patients defined as SGA by IG-21 was higher than by Fenton, in agreement with the literature. 9.7% ($n = 11$) of the patients defined as AGA by Fenton charts were defined as SGA by IG-21. This raises the question of whether the IG-21 is more sensitive in detecting infants with SGA.

Reddy et al. reported that 82.6% of infants with EUGR by Fenton's birth weight at discharge were defined as EUGR by IG-21 [17]. Tuzun et al. [19] in their retrospective study of 248 preterm infants with a mean gestational age of 29.1 weeks showed that the SGA rate at birth was significantly higher in IG-21 compared to Fenton (15% vs. 12%), while the EUGR rate at discharge was lower (31.5% vs. 40.2%). Our study showed similarity in comparison but with higher rates of EUGR at discharge weight (Fenton 66.3% vs. IG-21 58%). 12.5% ($n = 15$) of patients defined as EUGR at discharge according to Fenton did not have EUGR according to IG-21. When evaluating the z-score difference between discharge and IG-21 anthropometric measurements, the z-score change for body weight was significantly higher in those with EUGR than in those without EUGR.

When we compared the mean birth and discharge z-scores of anthropometric measurements according to the Fenton and IG-21 charts, it was seen that the IG-21 averages for weight and length were much higher. However, the head circumference percentile and z-score at birth and discharge were calculated to be lower than IG-21. In conclusion, when the infants are evaluated by IG-21 at birth and at discharge, the rates of SGA and EUGR change significantly. The Fenton, which was rearranged in 2013, is a projection created by taking the WHO charts to coincide with the WHO charts after the 50th week of gestation. The Fenton data were collected retrospectively, and there was insufficient data to standardize the measurements of the included studies and the methods of calculating the gestational week. Fenton also includes data for Germany, the United States of America, Italy, Australia, Scotland, and Canada with high socioeconomic status. Another important concern with Fenton is that it does not take into account the weight loss that occurs with physiological adaptation in the first postnatal week, as it is a curve based on intrauterine growth [20]. The IG-21 project is a multicenter, multiethnic, population-based prospective study [5]. The pregnant women included in the study were selected according to strict guidelines, as mentioned above, and the growth of infants with optimal intrauterine conditions who received an optimal postnatal diet based on human milk was prospectively monitored.The measurements were made on the basis of standardization and each measurement was double-checked, which surpasses the Fenton in terms of the reliability of the measurements.The mean gestational week in the IG-21 study was 35.5 ± 1.7 weeks.While there are 34,639 infants at < 30 weeks gestation in the Fenton charts, there are only 12 infants between 27 and 32 weeks in the IG-21.This raises questions about how reliable the IG-21 can be in following infants at < 33 weeks gestation. The WHO recommends a sample size of at least 200 to establish longitudinal prospective standards, and a total of more than 3500 measurements were made on 201 infants included in the IG-21 project [21]. This is another point of debate as to whether the number of patients or the number of anthropometric measurements is more important. In conclusion, IG-21 and Fenton have positive and negative aspects for optimal growth monitoring.

Our study had several limitations. The first one is that all the anthropometric data were obtained from the patients' records because it was a retrospective study, and the second one is that our cohort had a high rate of SGA because we are a referral center. However, the number of patients enrolled and the differences shown between the charts make it valuable for future research.

Conclusions

Universal growth charts should be appropriate for use in all populations, should tend toward standardized categorization of patients, and should be as sensitive as possible in the follow-up of critically ill patients, such as very low birth weight infants. Close follow-up of preterm infants is important to prevent or minimize short- and long-term adverse outcomes during their time in the NICU. Pediatricians who follow premature infants after discharge should closely monitor and improve their growth and developmental profiles to prevent or minimize the effects of problems encountered in the early infant period [22].

Abbreviations

EUGR Extrauterine Growth Restriction
SGA Small For Gestational Age
AGA Appropriate For Gestational Age
IG-21 INTERGROWTH-21ST
ELBW Extremely Low Birth Weight
C/S Caesarean Section
SD Standard Deviations

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Author contributions
IT: Conceptualization, Methodology, Formal analysis, Investigation, Visualization, Writing - Original Draft, OE: Writing - Review & Editing, Conceptualization, Supervision, Project administration. EK: Writing - Review & Editing. EO: Writing - Review & Editing. BA: Writing - Review & Editing. SA: Writing - Review & Editing.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the principles of the Declaration of Helsinki. The approval was granted by the Ethics Committee of the Ankara University (04/2020). Written parental consent to participate was obtained.

Consent for publication
Consent to publish has been received from all partecipants.

Competing interests
All authors have nothing to declare.

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