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**Original Research Article**

# The centrality of regional growth charts in the categorization of neonates as small for gestational age

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## ABSTRACT

**Background:** This paper presents a study which is based on the application of international and national growth charts on the same neonates. The study was conducted at the Safdarjung Hospital, Ansari Road, New Delhi, India.
**Methods:** International and regional growth charts were applied on the physical parameters of the same neonates to categorize them into the large for gestational age (LGA), appropriate for gestational age (AGA) or small for gestational age (SGA) categories.
**Results:** It was found that the SGA status and outcomes predicted by the regional chart were more accurate in terms of expected health issues in the neonates.
**Conclusions:** The value of regional growth charts is massive in taking measures to safeguard the life and health of neonates. A consciousness about the impact of neonates' weight should be spread amongst everyone. Regional growth charts are valuable for accurate assessment.

**Keywords:** Birth-weight, Community consciousness, Gestational age, Growth charts, Neonates, Regions

## INTRODUCTION

Anthropometry found its way into the human life long ago.[1] Some pioneers in the field are: Count Philibert de Montbeillard (1720-1785), George Buffon (1707-1788), Adolphe Quetelet (1796-1874), Charles Roberts (d. 1901), Francis Galton (1822-1911) and Henry Pickering Bowditch (1840-1911). The intergrowth charts were developed in 2014 and the WHO fetal Growth Charts were developed in 2018. In fact, growth is a complicated matter.[2] Thus, the study of growth has to be multi-disciplinary.[3]

Birth weight and weight in infancy are corelated.[4] Bergeman and Bergeman say that birth weight has negative correlations with weight and length during the first few months but is positively corelated with weight increments later in infancy.[5] The impact of birth weight on BMI and the development of non-insulin dependent diabetes mellitus is debated.[6] Studies associate birth weight in relation to gestational age with primary hypertension.[7] Socio-economic backdrop is vital.[8] Maternal age, altitude massive physical excursion, general state of physical and mental health, consumption of alcohol or smoking by the mother, lack of appropriately nutritive diet, attempts of therapeutic abortion, genetic predisposition and intrauterine growth retardation are some of the factors that can trigger LBW scenario.

The objectives of this study were to compare the prediction of in-hospital neonatal mortality and/or adverse outcome amongst the newborns classified as SGA (weight below 10th centile on respective growth charts) by the WHO fetal charts, Intergrowth 21st newborn cross-sectional and regional charts by Ghosh et al. The sensitivity, specificity, PPV (Positive Predictive Value) and NPV (Negative Predictive Value) of each chart for identifying small for gestational age neonates was also to be calculated.

## METHODS

This study was a comparative analysis of the application of the Shanti Ghosh regional chart, Intergrowth and WHO charts on the same set of neonates born in the Safdarjung Hospital in New Delhi. The period of the study was 1st January 2023 to 24th July 2023. It was a prospective cohort study. They were categorized as the Large for gestational age (LGA).

Appropriate for gestational age (AGA) or small for gestational age (SGA). The study involved neonates between 26 and 42 weeks of gestation The sample size for the study was based on a study by Anand et al, who reported the difference in mortality of 9% with the use of two charts. The sample size was calculated according to the formula given by Leeshawn et al, 1990.

Sample size N =Proportion of subjects with Difference in Growth Charts: p=0.09 (9%). Precision: $\delta$ =0.05 (5%) Type I error: $\alpha$ = 0.05 (5%)=1.96 Based on the formula and values given above.

Sample size required $N=(1.96^2 \times 0.09 \times (1-0.09)/0.05^2 = 125.85 \approx 126$

Thus, 95% confidence interval, the proposed sample size for the study was 126. So, enrollments were made till 126 in-hospital mortality in enrolled neonates were documented. Definitions used in the study.

### *Small for gestational age*

Neonates with birth weight below 10th centile for that gestation on any of the three charts

### *Appropriate for gestational age*

Neonates with birth weight between 10th and 50th centile for that gestation on any of the three charts

### *Large for gestational age*

Neonates with birth weight more than 90th centile for that gestation on any of the three charts

### *In hospital neonatal mortality*

Death of the enrolled neonate during hospital stay.

### *Adverse outcomes*

*Symptomatic hypoglycemia*

Any hypoglycemia needing intravenous dextrose as per standard unit protocol

Feed intolerance/non initiation of feeds by 48 hours of life: Feed intolerance as defined by one of the following.

Altered feed aspirates, abdominal distension>2 cm, feed aspirates>50% of previous feeds.

### *Inclusion criteria*

All inborn neonates born between gestational age of 26 weeks to 42 weeks.

### *Exclusion criteria*

Neonates with gross congenital malformations diagnosed within 24 hours of birth. Neonates enrolled in other randomized trials

They were weighed in the delivery room. Gestation was usually estimated by LMP, first trimester ultrasound or Expanded Ballard scoring in that order. Occurrence of neonatal mortality, symptomatic hypoglycemia and feed intolerance/ no feeds for 48 hours were recorded. The centiles for the regional charts by Ghosh et al were obtained using get data digitizer app, birth details, date of birth, gender, birth weight, morbidity, sepsis, antibiotics and oxygen for more than 48 hours.

The data was recorded in MS Excel spreadsheet SPSS v23 (IBM Corp.) and was analyzed. Descriptive statistics were elaborated in the form of means/standard deviations and medians/IQRs for continuous variables and frequencies and percentages for categorical variables. The data was processed in a graphical manner wherever appropriate for data visualization using histograms/box-and-whisker plots/column charts for continuous data and bar charts/pie charts for categorical data.

Normality for continuous data was checked using Shapiro-Wilk Test. Group comparisons for continuously distributed data were made using independent sample ‘t’ test when comparing two groups and One Way ANOVA when comparing more than two groups. Post-Hoc pairwise analysis was performed using Tukey’s HSD test in case of One-Way ANOVA to control for alpha inflation. Chi-squared test was used for group comparisons for categorical data.

Linear correlation between two continuous variables was explored using Pearson’s correlation (if the data was normally distributed) and Spearman’s correlation (for non-normally distributed data). Statistical significance was kept at $p<0.05$. Sensitivity, specificity, NPV (Negative Predictive Value) and PPV (Positive Predictive Value) was calculated for each chart using 2 by 2 table.

## RESULTS

The study enrolled 2238 neonates. The study cohort had a mean birth weight of 2.54±0.56. kgs and a mean gestation period of 37.54±2.43 weeks. Percentage of females enrolled in the study were 51.7%. Based on Intergrowth chart, 23.9% were classified as SGA, 73.7% were classified as AGA and finally 2.4% were classified as LGA. Based on WHO chart, 54.5% were classified as SGA, 43.5% were classified as AGA and 2% were classified as LGA.

Based on Shanti Ghosh chart, 10.6% were classified as SGA, 84.6% were classified as AGA and 4.7% were classified as LGA. Out of the total enrolled neonates, 91.7% were discharged without any of the adverse outcomes being documented. 127 neonates died during our study period which accounted for 5.6% of the enrolled neonates. 47 neonates developed hypoglycemia while 10 neonates developed feed intolerance and 5 neonates had an inability to initiate feeds.

These accounted for 2.1%, 0.4% and 0.2% of the enrolled neonates respectively. It was found that the Shanti Ghosh regional chart had the highest specificity and PPV in identifying neonates at risk for development of adverse neonatal outcomes.

**Table 1: Basic details of the study participants.**

| Basic details | Mean±SD | Median (IQR) | Min-Max OR N (%) mode of delivery |
|---|---|---|---|
| **VD** | 1319 (57.8%) | | |
| **LSCS** | | | 964 (42.2%) |
| **Gestation (Weeks)** | 37.54±2.43 | 37.86 (36.43-39.29) | 26.00-42.00 |
| **Gestation** | | 700 (30.7%) | |
| <37 weeks | | | |
| >37 weeks | | 1583 (69.3%) | |
| **Baby gender** | | | |
| Male | | 1102 (48.3%) | |
| Female | | 1181 (51.7%) | |
| Resuscitation (Required) | | 233 (10.2%) | |
| **Resuscitation done** | | | |
| Initial steps | | 140 (60.3%) | |
| PPV | | 65 (28.0%) | |
| Intubated | | 22 (9.5%) | |
| Chest compression | | 5 (2.2%) | |
| Multiple births (Yes) | | 78 (3.4%) | |
| **Birth weight (kg)** | 2.54±0.56 | 2.65 (2.20-2.90) | 0.55-4.10 |
| **Birth weight** | | | |
| <1 kg | | 28 (1.2%) | |
| 1-1.5 kg | | 82 (3.6%) | |
| 1.5-2.5 kg | | 775 (33.9%) | |
| ≥2.5 kg | | 1398 (61.2%) | |
| **Outcome** | | | |
| Discharged | | 2094 (91.7%) | |
| Death | | 127 (5.6%) | |
| Hypoglycemia | | 47 (2.1%) | |
| Feed intolerance | | 10 (0.4%) | |
| Inability to initiate feed | | 5 (0.2%) | |

**Table 2: Comparative neonatal outcomes.**

| Outcome | Discharged (n=2094) (%) | Death (n=127) (%) | Hypoglycemia (n=47) (%) | Feed Intolerance (n=10) (%) | Inability to initiate feed (n=5) (%) | P value |
|---|---|---|---|---|---|---|
| **Size for age (intergrowth)** | | | | | | |
| SGA | 427 (78.3) | 73 (13.4) | 34 (6.2) | 7 (1.3) | 4 (0.7) | <0.0013 |
| AGA | 1621 (96.3) | 52 (3.1) | 7 (0.4) | 2 (0.1) | 1 (0.1) | |
| LGA | 46 (83.6) | 2 (3.6) | 6 (10.9) | 1 (1.8) | 0 (0.0) | |
| **Size for age (WHO)** | | | | | | |
| SGA | 1088 (87.5) | 105 (8.4) | 38 (3.1) | 8 (0.6) | 5 (0.4) | <0.0013 |
| AGA | 965 (97.2) | 20 (2.0) | 6 (0.6) | 2 (0.2) | 0 (0.0) | |
| LGA | 41 (89.1) | 2 (4.3) | 3 (6.5) | 0 (0.0) | 0 (0.0) | |

Continued.

| Outcome | Discharged (n=2094) (%) | Death (n=127) (%) | Hypoglycemia (n=47) (%) | Feed Intolerance (n=10) (%) | Inability to initiate feed (n=5) (%) | P value |
|---|---|---|---|---|---|---|
| **Size-for-age (Shanti Ghosh)** | | | | | | <0.0013 |
| SGA | 167 (68.7) | 46 (18.9) | 21 (8.6) | 6 (2.5) | 3 (1.2) | |
| AGA | 1829 (94.7) | 78 (4.0) | 20 (1.0) | 3 (0.2) | 2 (0.1) | |
| LGA | 98 (90.7) | 3 (2.8) | 6 (5.6) | 1 (0.9) | 0 (0.0) | |

**Table 3: Size for age data.**

| Size-for-age | SGA (%) | AGA (%) | LGA (%) |
|---|---|---|---|
| **Intergrowth** | 545 (23.9) | 1683 (73.7) | 55 (2.4) |
| **WHO** | 1244 (54.5) | 993 (43.5) | 46 (2.0) |
| **Shanti Ghosh** | 243 (10.6) | 1932 (84.6) | 108 (4.7) |

## DISCUSSION

In context of regional accuracy, the Shanti Ghosh charts were excellent.[9] They accounted the length, weight and head circumference of the babies from 28 to 44 weeks of gestation measures prospecting 1 on 5000 consecutive single live birth. When compared to the other charts a downward divergence was seen in the weight curves between the 34 and 36 weeks. A divergence was seen at 37 and 38 weeks of length and head circumference.

This was attributed to maternal undernutrition, anemia and toxemia. Some other Indian charts are: AIIMS Singh et al, Mohan et al, Mathai et al, Kumar et al, Anand et al. In 2019, 47% of all the deaths before 5 years of age were in the newborn period.[10] The WHO fetal charts classified 54.5% of the study cohort as SGA compared to 23.9% classified as SGA based on Intergrowth chart and 10.6% based on Shanti Ghosh Chart. Out of our total enrolled neonates, 5.6% died, 2.1% had hypoglycemia, 0.4% developed feed intolerance and 0.2% developed inability to initiate feed.

The WHO chart was the most sensitive at detecting adverse outcomes with a sensitivity of 82.7% for predicting in-hospital mortality in comparison to 57.5% and 36.2% of the Intergrowth and Shanti Ghosh respectively. The specificity for detecting neonatal mortality was highest with Shanti Ghosh at 90.9%.

Intergrowth chart and WHO chart recorded 78.1% and 47.2% respectively. In prediction of secondary outcomes of hypoglycemia, feed intolerance and inability to initiate feed, the WHO chart had the highest sensitivity of 80.9%, 80% and 100%. The specificity for predicting the secondary outcomes was highest with Shanti Ghosh at 92%.

The Ghosh chart fared better with regards to the PPV; with a PPV of 18.9% for neonatal mortality compared to 13.4% and 8.4% of Intergrowth and WHO chart respectively. So, a neonate classified SGA by Shanti Ghosh had the highest propensity to develop an adverse outcome compared to the other 2 charts. The latter seemed inclined to overclassify SGA. In studies conducted in Canada, Indonesia, Nepal and South India and Ethiopia the value of regional charts was acknowledged.[11-14] They were in sync with reports of Hasthi et al, from India.[15] Boghossian et al from USA also confirmed the same.[16] A study conducted in Rio de Janeiro asserted that prematurity was a better predictor of adverse neonatal outcomes.[17]

A multicentre study found that the intergrowth chart was a good predictor of hypoglycemia as an adverse outcome.[18] A European study asserted that intergrowth inclined to show a lower prevalence of SGA and a higher prevalence of AGA.[19]

A study conducted in Latin America concluded that the diagnostic performance of Intergrowth exceeded that of WHO chart.[20] A Portuguese study had the same conclusion.[21] A study on 68,897 neonates comparing diagnostic accuracy showed that WHO charts had a sensitivity of 42% in identifying SGA while Intergrowth had a sensitivity of 19%.[22] A Brazilian study showed that Intergrowth detected lesser number of SGA compared to WHO charts.[23]

A study comparing regional and international charts in Lithuania noted a variation of 6 % in their respective readings.[24] Over-diagnosing SGA can prompt unnecessary medical interventions and under-diagnosing SGA can result in missing opportunities of life saving.

### *Limitations*

Firstly, the study was conducted at a single center. Secondly the neonates were observed only during their stay in the Hospital. Thirdly, in settings where accurate dates of LMP and 1st trimester USG are not available the exact methods employed in this study will encounter limitations.

## CONCLUSION

It was concluded that the regional growth charts can be the most accurate classifiers of the SGA and the best predictors of adverse neonatal outcomes. The more specific the charts are the more accurate they will be. Awareness about noting LMP dates is vital. Efforts must be made to develop regional growth charts because they balance the real weight of a neonate with a 'really' expected weight in the local context.

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