

Research Article

Assessment of fetal malnutrition by body mass index and intra uterine growth curves: a comparative study

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ABSTRACT

Background: Assessment of fetal malnutrition (FM) is incomplete by intra uterine growth (IUG) charts where only single anthropometric measure like weight is used. Body mass index (BMI) is a weight to length ratio which is a sensitive indicator of malnutrition. This study was aimed at comparing the accuracy of various birth weight based IUG charts with Body mass index of the new-born babies in detection of FM and correlating the neonatal complications with the BMI and the birth weight.

Methods: A cohort study was done with a sample of 1192 newborn babies with gestational ages from 34 to 40 weeks. The newborns were classified based on BMI and birth weight after plotting on the BMI charts and various IUG charts. The accuracy of the various IUG charts in identifying FM when compared to BMI was analyzed and correlated with neonatal complications.

Results: The prevalence of FM was 26.59% on classifying using BMI charts which was the highest when compared to the IUG charts. The IUG charts misclassified the undernourished babies as well nourished. The incidence of complications was 26.3% among the babies with low BMI when compared to normal BMI (14.8%). The classification of the newborns according to IUG charts did not correlate with incidence of complications.

Conclusions: BMI chart is most sensitive indicator of FM at birth and its use is highly recommended in a developing country like India. It helps us to target the under nourished babies, provide better nutritional care and also anticipate and prevent neonatal complications.

Keywords: Body Mass Index, Fetal Malnutrition, Intra uterine growth curves, Perinatal complications

INTRODUCTION

Fetal malnutrition is a significant problem in developing countries. Of the 95.6% of the low birth weight (LBW) babies born in developing countries, India accounts for 40% (7.8 million) of LBW. These undernourished newborns are at high risk for perinatal complications like birth asphyxia, sepsis, hypoglycemia, hypocalcemia and also long term problems like decreased cognitive abilities and higher risk of diabetes and hypertension during adulthood.¹ Hence, detecting under nutrition at birth becomes important so that these babies can be monitored for complications and growth failure.

There are various methods which are being followed in the nurseries for nutritional assessment. The most widely used are birth weight based Intra uterine growth (IUG) charts extrapolated from various populations.² The popular ones are the IUG charts compiled by Olsen et al and Lubchenco et al.^{2,3} The most recent and reliable gender specific IUG charts are the one compiled by Olsen et al based on a large population of 391,681 racially diverse infants from 248 hospitals in the US.² Lubchenco charts are based on data collected between 1940s and 1960s from 5000 white infants from a single NICU in Colorado.³ The growth charts compiled based on a cohort of newborns from a tertiary hospital in North India are

used in some Indian hospitals.⁴ These charts classify babies based on the birth weight into small, appropriate and large for the gestational age. The fetal malnourishment can get underestimated by these charts since a proportion of malnourished infants can still have normal weight for that gestational age.⁵ The other methods are based on either individual anthropometric parameters like mid arm circumference, or their ratios, for example mid arm circumference to head circumference (MAC/HC) ratio.⁶

Growth assessment is not complete when only one anthropometric parameter like weight is used since it does not identify growth that is disproportionate i.e. whether the baby's in utero weight gain is too low or high for the length. Based on this concept, various weights to length ratios have been studied like body mass index (BMI) and ponderal index (PI). Previous studies have concluded that fetal malnutrition is best assessed by weight to length ratios when compared to other parameters where only one anthropometric measure is used and have high sensitivity in detecting fetal malnutrition when compared to the weight criteria.⁷⁻¹⁰ Using these ratios help us in detecting more number of undernourished newborns and to be aggressive in delivering nutritional care and entitling strict growth monitoring. BMI curves provide a simple, objective and more accurate method to identify and quantify disproportionate growth in newborns and hence seem to be reliable in estimating the nutritional status.

Olsen et al recently published validated BMI charts based on a large newborn population from various hospitals from the US.⁵ These charts are gender specific and available for babies with gestational age between 22 and 42 weeks. This is the most recent chart based on weight to length ratio after those published by Lubchenco et al in 1966 and Miller and Hassanein in 1971.^{11,12}

This study was aimed at comparing the accuracy of various intrauterine growth charts which are based on the birth weight with BMI of the newborn babies in detection of fetal malnourishment and correlating the neonatal complications with the BMI and the birth weight. The outcome of this study throws light on the usefulness of BMI charts and propagates its use in the nurseries.

METHODS

Study setting, design and population

This study was conducted with a birth cohort of 1192 neonates born in a tertiary teaching hospital. The babies born between July 2014 and December 2015 with gestational age between 34 to 40 weeks were enrolled. Preterms less than 34 weeks of gestation and babies born with major congenital malformations and suspected intrauterine infections were excluded from the study.

The demographic and anthropometric data were retrieved from the medical records. The inter observer bias was minimal since standard methods were used to measure the weight, length and head circumference which was constantly reinforced among residents.

Neonatal data at delivery included Apgar, maturity and growth parameters. Maturity was based on maternal dates and ultrasonogram. In case of a discrepancy of ± 2 weeks, the neonate modified Ballard's scoring was used to assess maturity. Gestational age between 37 completed and 42 weeks were classified as term, <37 completed weeks pre-term and 34 completed and 37 weeks as late preterm. Weight was recorded to the nearest 0.001 kg in calibrated electronic weighing scale, length in cm in an infantometer and head-circumference in cm with a non-stretchable measuring tape.

Nutritional assessment

Nutritional assessment was done by two methods. Firstly, the body mass index was calculated using the formula: weight in kilograms/ length in metre² and plotted on the gender specific BMI charts by Olsen et al⁵ BMI less than tenth percentile was considered as fetal undernutrition. Then, neonates were classified into appropriate for gestational age (AGA) if their birth weights ranged between 10th and 90th centiles for that gestational age, small for gestational age (SGA) if their weights fell below 10th centile or large for gestational age (LGA) if their weights were more than 90th centile on the various intra uterine growth charts. Three IUG charts commonly used in the nurseries namely Lubchenco, Olsen and Indian charts were used.²⁻⁴

Any documented neonatal complications like birth asphyxia, hypocalcemia, hypoglycaemia, non-physiological hyperbilirubinemia and sepsis were recorded. Hyperbilirubinemia due to blood group incompatibility were excluded.

Statistical analysis

All data were entered in excel. Analysis of data was done by using statistical software SPSS version 16. Comparison between the IUG charts was done using Chi-square test. The parametric data were represented as mean \pm SD with 95% Confidence Interval (CI). The various growth charts were compared with BMI and Odds ratio was calculated. The validity measurements were calculated using standard formulae. Statistical significance was assumed if p value was <0.05.

RESULTS

Demography

A total of 1192 newborn babies, 1094 term and 98 late preterm, were enrolled in the study. Of this 585 (49.1%) babies were females and 607 (50.9%) were males. The

mean birth weight was 2330±0.547 grams and 3010±0.428 grams among the late preterm and term respectively. The mean length was 49.47±2.33 cm. The mean head circumference was 33.8±1.39 cm.

The mean BMI was 12.03+1.507 kg/m²; 10.61+1.71 kg/m² among the late preterms and 12.15+1.52 kg/m² among the term babies.

Nutritional assessment

The BMI was less than tenth centile in 317 (26.59%) newborns and hence considered undernourished.

Among the undernourished, there were 29.1% females and 25.7% males. There was no significant difference in the prevalence of under nutrition among the males and the females (p=0.332).

Of the undernourished, 24.5% were late preterm and 27.6% of the term newborns. There was no significant difference in the prevalence of undernourishment among various gestational ages (p=0.780).

The reliability of the three IUG charts in detecting undernourishment when compared to BMI was analyzed.

According to the IUG charts only 43(3.04 %), 84(7.3 %) and 286(23.99%) newborns were SGA according to Indian, Lubchenco and Olsen chart respectively (Table 1).

Table 1: Prevalence of malnutrition according to BMI and Intra uterine growth charts by Olsen et al, Lubchenco et al and Indian chart.

Study	Criteria	Undernourished (%)	Normal (%)
Olsen et al	BMI<10 th percentile	317(26.59)	75 (73.41)
Olsen et al	Birthweight <10 th centile	286(23.99)	906 (76.01)
Lubchenco et al	Birthweight <10 th centile	84(7.04)	1108 (92.96)
Indian Chart	Birthweight <10 th centile	43(3.60)	1149 (96.4)

According to Olsen, Lubchenco and Indian charts 11.8%, 23.4% and 29.9% of the AGAs respectively had low BMI (Table 2). This difference was statistically significant (p<0.001).

Table 2: Comparison between BMI and intrauterine growth charts.

		BMI		χ ²	p value	Odds ratio	95% CI
		Low (%)	Normal (%)				
Olsen et al	SGA	222 (77.6)	64 (22.4)	638.74	<0.001	25.61	18.13 to 36.18
	AGA	104 (11.8)	768 (86.9)				
Lubchenco et al	SGA	83 (94.3)	5 (5.7)	304.41	<0.001	54.44	21.83 to 135.78
	AGA	243 (23.4)	797 (76.7)				
Indian chart	SGA	40 (97.6)	1 (2.4)	228.05	<0.001	118.18	16.17 to 863.58
	AGA	286 (29.9)	845 (99.9)				

When IUG charts by Olsen et al, Lubchenco et al and Indian charts were applied, 2.6 %, 19.55% and 22.99% of undernourished newborns were missed and classified as AGA. This difference was statistically significant (p<0.001).

The various IUG charts were compared among each other. It was found that 198 newborns classified as AGA under Lubchenco were actually SGA under Olsen IUG charts and this was statistically significant (p<0.001).

Similarly, the Indian growth chart claimed 244 new borns as AGA, but they were SGA according to Olsen IUG charts. This was a statistically significant difference (p<0.001).

Comparison of validity measurements of the various charts in comparison with BMI are depicted in Table 3.

When compared to BMI charts IUG charts by Olsen et al was the most sensitive in detecting under nutrition (sensitivity 68%) among three IUG charts compared. This indicates that Olsen IUG chart is most sensitive in detecting undernourishment and overall all the charts are underestimating the malnutrition.

The incidence of perinatal complications among the low BMI newborns (26.3%) when compared to those with normal BMI (14.8%) was high and this difference was statistically significant (p<0.001).

The incidence of perinatal complications among the AGA babies according to Olsen, Lubchenco and Indian chart was 35.7%, 38.2% and 32.7% respectively. The babies who were large for gestational age were included along with AGA for correlation of complications since they were few in number. Among 215 babies who had

complications, 83 (38.6%) were SGA and 132 (61.4%) were AGA according to Olsen IUG chart, 184 (85.6%) were AGA and 31 (14.4%) were SGA according to Lubchenco, 197 (91.6%) were AGA and 18 (8.4%) were SGA according to Indian charts.

Table 3: Sensitivity, specificity, positive and negative predictive values of the various intrauterine growth charts when compared to BMI.

IUG charts	Olsen et al	Lubchenco et al	Mehrban Singh
Sensitivity	68%	25%	12.2%
Specificity	92%	99.3%	99.8%
Positive Predictive Value	77.6%	94%	97.5%
Negative Predictive Value	77.9%	76%	69.9%

Among the babies who had sepsis 50% were AGA and 50% were SGA according to Olsen chart; 76.1% were AGA and 23.9% SGA according to Lubchenco; 87.1% AGA and 12.9%.SGA according to Indian growth charts.

Among the babies who had hypoglycemia 44.4% were AGA and 54.6% were SGA according to Olsen chart;66.7.1% were AGA and 33.3% SGA according to Lubchenco; 72.2% were AGA and 22.8.% SGA according to Indian growth charts.

Among the babies who had hyperbilirubinemia were 57.1% AGA and 42.9% were SGA according to Olsen chart; 82.2% were AGA and 17.8% SGA according to Lubchenco; 72.2% were AGA and 22.8.% SGA according to Indian growth charts.

This observation of high incidence of complications among the AGA babies may be due the inclusion of those undernourished newborns with complications who were wrongly classified as AGA.

DISCUSSION

The developing countries contribute significantly to the burden of low birth babies born globally. These undernourished babies are prone to perinatal complications like birth asphyxia, hypoglycemia, hypocalcemia and poor neuro developmental outcome, whether small or appropriate for gestational age. There is another group of innately small neonates whose small size is proportionate to the length and they are not actually malnourished.¹³

The extensively used birth weight based intrauterine growth charts under estimate the fetal malnourishment.⁷⁻¹⁰ Weight to length ratios assess the body fat content in relation to the length and have been

found reliable in detecting disproportionate growth. Body mass index (BMI) has been widely used for nutritional assessment and adiposity in children however underutilized in neonates.⁵ This was partly due to lack of reference standards for different gestational ages. Olsen et al published reference BMI curves in 2015 and concluded that disproportionate growth failure in infants is best detected by gender specific BMI for age percentile curves when compared size for age methods.⁵ BMI is a good tool since it takes into account both stature and weight of the newborn and also correlates with neonatal complications of malnourished newborns.⁹

In our study newborns were classified as undernourished if their BMI was less than tenth percentile according to the charts by Olsen et al.⁵ BMI was taken as the gold standard since previous studies have shown that it is most sensitive in detecting under nutrition.⁷ BMI also correlates well even with CAN score which is reliable but time consuming method.⁷ Also, when compared to other weight to length ratios like Ponderal index BMI is highly reliable.⁸ BMI also correlates well with body fat percentage which is the actual measure of in utero nutrition.¹⁴⁻¹⁶

The incidence of fetal malnutrition in our study was 26.59% according to BMI charts which is less in comparison with studies by Soundarya et al and Thammanna et al where it was 40.3 % and 39.45% respectively.^{7,8} However, in our study we have used standardized gestational age and gender specific BMI percentile curves unlike those studies. BMI did not show any significant difference among the gender which was similar to other studies.^{7,8}

The mean BMI was 12.15+1.52 among the term newborns in our study which is high when compared to 11.7±1.7 kg/m² and 11.35±1.53 kg/m² in studies done in India by Thammanna et al and Kamalammal et al respectively.^{8,9} It is lower than the mean BMI of 13.25±1.11 kg/m² in a study by Brock et al done in Brazil.¹⁴

The BMI did not show any statistically significant difference among females and males which is in agreement with other studies.^{9,14}

We compared various birth weight based IUG charts mentioned above which are widely used in the nurseries to assess the nutritional status. The number of babies classified as SGA according the growth charts were significantly less when compared to actually undernourished babies. In comparison with BMI, the other IUG charts were less sensitive in detecting under nutrition. Hence undernourished newborns were wrongly classified as AGA and hence these newborns who were still at risk for perinatal and long term complications were missed. Among the three IUG charts the one by Olsen et al was the most sensitive in detecting malnutrition. The other two charts were highly specific

though lacked sensitivity and missed significant number of undernourished newborns.

In our study we observed that the incidence of perinatal complications like hypoglycaemia, hyperbilirubinemia and sepsis were significantly high among the low BMI babies. The incidences of same complications were almost similar among SGA and AGA babies. This observation was probably due to the inclusion of undernourished babies as AGA. Hence, using BMI charts will also help us in anticipating, preventing these complications and individualizing the method of nutritional rehabilitation.

The population from which the BMI chart was created by Olsen et al was a racially diverse, large population with mean birth weight of 3007 grams among males 2831 grams among females and mean length of 48.91 cms among males and 48.12 cms among females with gestational age between 34 and 40 weeks which is comparable to our population (mean birth weight of 2980 grams among males 2924 grams among females and mean length of 49.58 cms among males and 49.35 cms among females) which is comparable to our cohort.^{2,5} Therefore, Olsen BMI charts are reliable and can be applied to our population also.

The limitation of our study is that the number of preterms recruited was small when compared to term babies. The limitation in using BMI is that babies with growth restriction resulting in stunting and low birth weight together may have normal BMI. In such conditions using BMI charts alone can be misleading.

In conclusion in developing countries like ours we need a tool which is very sensitive in detecting under nutrition in newborn babies so that these babies are nutritionally rehabilitated. Also these babies can be considered as high risk babies and meticulously monitored for complications and followed up for long term morbidity. Hence, the use of BMI charts in conjunction with weight, length and head circumference for age growth charts are greatly recommended for complete assessment of nutrition in the newborns.

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REFERENCES

1. Ezenwa BN, Ezeaka VC, Ihora E, Egri-Okwaji MT. Determination of Fetal Malnutrition in Preterm new borns. *J Food Nutr Sci.* 2013;1:50-6.
2. Olsen IE, Groveman SA, Lawson L, Clark RH, Zemel BS. New intrauterine growth curves based on United States data. *Pediatr.* 2010;125:e214-23.
3. Lubchenco LO, Hansman C, Dressler M, Boyd E. Intrauterine growth as estimated from live born

- birth-weight data at 24 to 42 weeks of gestation. *Pediatr.* 1963;32:793-800.
4. Singh M. Care of the newborn. 8th ed. Noida: CBS Publishers;2015:310.
5. Olsen IE, Lawson L, Ferguson AN, Cantrell R, Grabich SC, Zemel BS et al. BMI curves for Preterm Infants. *Pediatr.* 2015;135:572-81.
6. Georgieff MK, Sasanow SR, Mammel MC, Periera GR. Mid-arm circumference/head circumference ratios for identification of symptomatic LGA,AGA and SGA new born infants. *J Pediatr.* 1986;109:316-21.
7. Soundarya M, Basavaprabhu A, Raghuvveera K, Baliga BS, Shivanagaraja BSV. Comparative Assessment of Fetal Malnutrition by Anthropometry and CAN Score. *Iran J Pediatr.* 2012;22:70-6.
8. Thammanna PS, Sandeep M, Sridhar PV. A comparative study to assess fetal malnutrition by Clinical Assessment of Nutritional Status Score (Can score) and anthropometric Indices. *J Evid Based Med Health.* 2015;2:5820-7.
9. Kamalammal R, Rao S, Parameshwari PJ. Body mass index values for term new borns and its correlation with other anthropometric surrogates. *Intl J Contemp Pediatr.* 2016;3:120-4.
10. Singhal V, Agal V, Kamath N. Detection of fetal malnutrition by CAN score at birth and its comparison with other methods of determining intrauterine growth. *Indian J Clin Pract.* 2012;22:576-81.
11. Lubchenco LO, Hansman C, Boyd E. Intrauterine growth in length and head circumference as estimated from live births at gestational ages from 26 to 42 weeks. *Pediatr.* 1966;37:403-8.
12. Miller HC, Hassanein K. Diagnosis of impaired fetal growth in new born infants. *Pediatr.* 1971;48:511-22.
13. Milovanovic I, Njuieyon F, Deghmoun S, Chevenne D, Levy-Marcha C, Beltrand J. Innate small babies are metabolically healthy children. *J Clin Endocrinol Metab.* 2012;97:4407-13.
14. Brock RS, Falcao MC, Leone C. Body mass index values for new borns according to gestational age. *Nutr Hosp.* 2008;23:487-92.
15. Olsen IE, Lawson L, Meinzen-Derr J, Sapsford AL, Schibler KR, Donovan EF et al. Use of body proportionality Index for Growth Assessment of Preterm Infants. *J Pediatr.* 2009;154:486-91.
16. De Cunto A, Paviotti G, Ronfani L, Travan L, Bua J, Cont et al. Can body mass index accurately predict adiposity in new borns? *Arch Dis Child Fetal Neonatal Ed.* 2014;99:F238-9.

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