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Original Research Article

ASSESSMENT OF FOETAL MALNUTRITION IN TERM NEONATES USING CLINICAL ASSESSMENT OF NUTRITIONAL STATUS (CAN) SCORE AND ITS COMPARISON WITH OTHER ANTHROPOMETRIC MEASUREMENTS: A HOSPITAL-BASED CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Foetal malnutrition (FM) is characterized by inadequate deposition of subcutaneous fat and muscle mass during intrauterine life and may occur irrespective of birth weight or gestational age. Early identification is important to prevent adverse neonatal outcomes. This study aimed to determine the prevalence of fetal malnutrition in term neonates using the Clinical Assessment of Nutritional status (CAN) score and compare it with conventional anthropometric indices. **Materials and Methods:** This hospital-based cross-sectional study was conducted at a tertiary care centre in South India between November 2019 and January 2022. A total of 299 term neonates were enrolled. Anthropometric measurements including birth weight, length, head circumference, mid-arm circumference (MAC), ponderal index (PI), body mass index (BMI), and MAC/head circumference (MAC/HC) ratio were recorded. CAN score was assessed within 48 hours of birth, with a score <25 indicating fetal malnutrition. Diagnostic performance of anthropometric indices was evaluated using CAN score as the reference standard. **Result:** Among 299 neonates, 114 (38.17%) had CAN score <25 suggestive of fetal malnutrition. Significant associations were observed between CAN score and weight for gestational age (p=0.033), BMI (p=0.037), and MAC/HC ratio (p<0.001). Malnutrition was identified in 51.72% of SGA, 38.4% of AGA, and 15% of LGA babies. The MAC/HC ratio demonstrated the highest diagnostic accuracy (72.24%) and specificity (83.78%). Maternal anemia showed a significant association with fetal malnutrition (p=0.035). **Conclusion:** CAN score is a simple, inexpensive, and reliable bedside tool for early detection of fetal malnutrition, particularly among AGA neonates. Among anthropometric indices, MAC/HC ratio showed the best diagnostic performance.

INTRODUCTION

Foetal malnutrition (FM) is a condition in which a foetus fails to develop a necessary amount of fat, the muscular mass, and subcutaneous tissue throughout intrauterine maturation due to insufficient availability and or use of nutrients.[1] Many factors influence foetal development, including the mother's nutrition2and social habits/status (e.g., smoke, education level), the state of the placenta3, and the foetus' genetic makeup.[2-4] Underweight / wasting of the clinical condition seen in malnourished babies is referred to as foetal malnutrition. This condition can affect babies of any birth weight, but it is more common in preterm babies.[5] Malnutrition is the leading cause of child mortality, according to the World Health Organization accounting for 50% of the childhood mortality in developing countries.[6] A reduction in the delivery and consumption of oxygen to the growing foetus is a common feature of most FM causes. Because diverse tissues grow at varying periods during foetal life and infancy, the protracted effects of altering nutrition are influenced by the

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timing and degree of the change. Due to the obvious potentially severe malnutrition sequelae on several major organs, determining the nutritional state of the foetus at delivery becomes a major concern. Perinatal problems and protracted central nervous system sequelae are predominantly more common in babies of either Appropriate for gestation age (AGA) or Small for gestational age(SGA).[4] Foetal malnutrition could be a cause of premature delivery.[5]

An intrauterine growth chart is commonly used to assess the nutritional condition of the infant. The baby is SGA if it falls below the 10th centile on the growth chart. Foetal growth accelerates when intrauterine nutrients and placental function are available. Preterm low birth weight neonates are treated differently than term low birth weight newborns. Malnutrition must be detected as soon as possible in order to prevent adverse consequences, hence early detection is critical. FM is a clinical syndrome that is independent of gestation or birth weight. Metcoff created a clinical assessment of nutritional status (CAN) score determined within 48 hours of birth based on nine superficially discernible clinical signs, including hairs, cheeks, neck, hands, torso, abdominal, lumbar, buttocks, and feet, to distinguish malnourished from adequately nourished babies.[7-8] The nutritional status of many AGA and SGA neonates can be determined by comparing CAN score readings to other anthropometric parameters. Some well-nourished SGA newborns are misinterpreted as malnourished likewise AGA babies as well nourished. Malnutrition detection will also assist us in providing parental counselling. The CAN score procedure is simple, systematic, scientific, and objective, making it ideal for routine screening of neonates for preventive treatment. The clinical signs and symptoms of foetal malnutrition vary depending on when it started during gestation. FM is not synonymous with SGA or IUGR.[8] Other anthropometric measures (weight, length, mid-arm circumference (MAC) and head circumference (HC), proportionality indices (ponderal index [PI], MAC/HC ratio, body mass index [BMI]) have been used to detect babies with inadequate foetal growth.

MATERIALS AND METHODS

The study was a hospital based cross sectional study carried out at a tertiary care centre in South India from November 2019 to January 2022. The research protocol was approved by the institute's ethics committee (Number: EC/47/2019). Written informed consent was obtained from all parents prior to enrolment. The objective of our study is to determine foetal malnutrition in term neonates based on a clinical assessment of nutritional status (CAN) score and to compare the CAN score with the other anthropometric measurements of the neonate in detecting foetal malnutrition. A total of 299 Term (37+ weeks of gestation including post term) neonates were enrolled in the study. All preterm babies, babies born out of multiple gestation, babies with congenital anomalies, mothers with diabetes and mothers whose last menstrual period was not known were excluded from the study. Basic antenatal and birth history were recorded including antenatal scans. Weight, Length, Head circumference (HC), Mid arm circumference (MAC), MAC / HC, Ponderal index (PI), Body Mass Index (BMI) and Clinical assessment of Nutritional status (CAN) score were measured using standard protocols. CAN score is applied to all included newborns and it was based on inspection of hairs, cheeks, neck and chin, arms, back, buttocks, legs, chest and abdomen and then score determined accordingly. The highest CAN score is 36, and the least score is 9. A CAN score of less than 25 is considered to be malnutrition.[8]

Gestational age assessed based on last menstrual period (LMP) and New Ballard Score.[9]

Babies were classified into term appropriate for gestational age (AGA), small for gestational age (SGA) or large for gestational age (LGA) after plotting on the appropriate growth charts. Babies falling below the 10th centile are classified as SGA, more than 90th centile are LGA and falling in between 10th and 90th centile are considered to be AGA.

Ponderal index (PI) is calculated by using the formula weight (gms) / length (cms)3 x 100. A ponderal index of less than 2.2gm/cm3 will be considered an index of malnutrition.

Mid arm circumference /head circumference ratio (MAC/HC): A cut off value of 0.30 was used to define malnutrition.

BMI is calculated using the formula: weight (kg) / length (m)2. A cut-off value of 11.20 kg/m2 was considered as an index of malnutrition.

Weight of the baby was measured using electronic weighing machine brand named 'Essae'. MAC, HC were measured using a non-stretchable inch tape and the length of the baby was measured using Infantometer with brand name of HHC.

Statistical analysis: Data were expressed as means with standard deviations or medians with interquartile ranges, as appropriate. Normally distributed data was compared by Student's t-test, non-normally distributed data with Mann-Whitney U test, and proportions by Chi-square/Fisher's exact test. SPSS 24.0 software (IBM SPSS, Chicago, Illinois) was used for analysis.

RESULTS

A Total Of 299 Babies Were Included In The Study Out Of Which 135 Were Male And 164 Were Female.

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Table 1 Depicts The Anthropometric Characteristics Of The Cohort:

Variable	Category/Parameter	Frequency (%) / Mean ± SD	Minimum	Maximum
Growth Classification (N=299)	SGA	29 (9.6%)	—	—
	AGA	250 (83.6%)	—	—
	LGA	20 (6.67%)	—	—
Birth Weight Classification	<2.5 kg	24 (8.03%)	—	—
	>2.5 kg	275 (91.97%)	—	—
Anthropometric Parameters	Birth Weight (kg)	2.96 ± 0.33	2.15	3.82
	Length (cm)	49.83 ± 1.24	45.00	53.00
	Head Circumference (cm)	34.17 ± 0.78	32.00	36.00
	Mid Arm Circumference (cm)	10.95 ± 0.78	9.00	12.50
	BMI	11.78 ± 0.78	9.90	13.90
	Ponderal Index	2.36 ± 0.18	1.80	2.90
	MAC/HC Ratio	0.31 ± 0.02	0.26	0.35
	CAN Score	25.22 ± 3.69	13.00	33.00
BMI Classification	<11.2 (Malnourished)	77 (25.75%)	—	—
	>11.2 (Well nourished)	222 (74.25%)	—	—
CAN Score	—	25.22 ± 3.69	13.00	33.00

Table 2: Comparison of CAN Score with Anthropometric Measurements in Detecting Foetal Malnutrition

Anthropometric Parameter	Category	CAN Score <25 N (%)	CAN Score ≥25 N (%)	P value
Weight for Gestation	SGA (N=29)	15 (51.72%)	14 (48.28%)	0.033
	AGA (N=250)	96 (38.4%)	154 (61.6%)	
	LGA (N=20)	3 (15%)	17 (85%)	
	Total (N=299)	114 (38.17%)	185 (61.87%)	
BMI	<11.2 (N=77)	37 (48.05%)	40 (51.95%)	0.037
	>11.2 (N=222)	77 (34.68%)	145 (65.32%)	
	Total (N=299)	114 (38.12%)	185 (61.87%)	
Ponderal Index	>2.2 (N=219)	77 (35.16%)	142 (64.84%)	0.080
	<2.2 (N=80)	37 (46.25%)	43 (53.75%)	
	Total (N=299)	114 (38.12%)	185 (61.87%)	
MAC/HC Ratio	<0.3 (N=91)	61 (67.03%)	30 (32.97%)	<0.001
	>0.3 (N=208)	53 (25.48%)	155 (74.52%)	
	Total (N=299)	114 (38.17%)	185 (61.87%)	

The comparison of CAN score with various anthropometric measurements demonstrated a significant association between foetal malnutrition and weight for gestation, BMI, and MAC/HC ratio. Among SGA neonates, 51.72% had a CAN score <25 compared to 38.4% of AGA and 15% of LGA babies (p = 0.033). Neonates with BMI <11.2 showed a higher proportion of CAN score <25 (48.05%) compared to those with BMI >11.2 (34.68%) (p = 0.037). Similarly, a MAC/HC ratio <0.3 was strongly associated with foetal malnutrition, with 67.03% of neonates having CAN score <25 compared to 25.48% among those with MAC/HC ratio >0.3 (p <0.001). Although neonates with ponderal index <2.2 had a higher proportion of CAN score <25 (46.25%) compared to those with ponderal index >2.2 (35.16%), the association was not statistically significant (p = 0.080). There was no statistically significant association between CAN score and sex of the neonate (p = 0.715). CAN score <25 was observed in 39.26% of boys and 37.2% of girls. Similarly, maternal age did not show a significant association with CAN score (p = 0.409), although neonates born to mothers aged >30 years had a relatively higher proportion of CAN score <25 (58.33%) compared to other age groups.

Also, maternal comorbidities showed a statistically significant association with CAN score (p = 0.035). Neonates born to mothers with anaemia had the highest proportion of CAN score <25 (70%). Higher proportions of foetal malnutrition were also observed among mothers with combined comorbidities such as GHTN with hypothyroidism and GDM with hypothyroidism, although the sample sizes were very small. In contrast, neonates born to mothers with GDM had a lower proportion of CAN score <25 (20.59%).

Table 3: Diagnostic Performance of Anthropometric Indices for Detecting Foetal Malnutrition Using CAN Score as Reference Standard.

Parameter	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	Diagnostic Accuracy % (95% CI)
BMI	32.46 (23.99–41.86)	78.38 (71.74–84.08)	48.05 (36.52–59.74)	65.32 (58.66–71.56)	60.87 (55.09–66.44)
Ponderal Index	67.54 (58.14–76.01)	23.24 (17.36–30.00)	35.16 (28.85–41.88)	53.75 (42.24–64.97)	40.13 (34.53–45.93)
Weight for Gestation	13.16 (7.56–20.77)	92.43 (87.63–95.80)	51.72 (32.53–70.55)	63.33 (57.28–69.09)	62.21 (56.45–67.73)
MAC/HC Ratio	53.51 (43.93–62.90)	83.78 (77.67–88.78)	67.03 (56.39–76.53)	74.52 (68.03–80.29)	72.24 (66.79–77.24)

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The MAC/HC ratio demonstrated the highest diagnostic accuracy (72.24%) and specificity (83.78%) among the anthropometric indices for detecting foetal malnutrition using CAN score as the reference standard. Weight for gestation showed the highest specificity (92.43%) but very low sensitivity (13.16%). Ponderal index demonstrated relatively higher sensitivity (67.54%) but poor specificity (23.24%). BMI showed moderate specificity (78.38%) but low sensitivity (32.46%) in identifying foetal malnutrition.

DISCUSSION

The present study was conducted to identify occult foetal malnutrition using the CAN score among term neonates, especially among those classified as term, appropriate for gestational age (AGA), and to compare the CAN score with other anthropometric measurements in detecting foetal malnutrition.

Small for gestational age (SGA) and foetal malnutrition are not synonymous entities. In developing countries such as India, the prevalence of low birth weight and maternal undernutrition is considerably higher than in developed nations.[10] Therefore, relying solely on the 10th percentile for gestational age to identify malnutrition may miss a substantial proportion of nutritionally compromised neonates. In addition, weight-for-gestational-age charts cannot reliably differentiate constitutionally small but healthy babies from truly malnourished neonates.[11]

The mean birth weight in the present study was 2.96 ± 0.33 kg, which was comparable to studies by Almarzoki et al., and Faheem et al.[12,13] Similarly, the mean birth length of 49.83 ± 1.24 cm in our study was comparable with previous studies, which reported a mean birth length of 49.37□ 2.26 to 49.38□2.2.[12-14]

In our study, 9.6% of neonates were classified as SGA, while 83.6% and 6.67% were categorized as AGA and LGA, respectively. Similar findings were reported by Metcoff et al. and Faheem et al.[8,13] In contrast, studies by Rao et al. and Liladhar et al. demonstrated a higher proportion of SGA babies.[15,16] This variation may be attributed to differences in maternal nutritional status, prevalence of maternal comorbidities during pregnancy, and socioeconomic factors across the study populations.

The incidence of foetal malnutrition detected using the CAN score in the present study was 38.17%, which was comparable to findings reported by similar Indian studies.[15,17-18] However, Metcoff et al. and Nanoti et al. reported considerably lower incidences.[8,19] These variations may be due to differences in socioeconomic conditions or genetic factors as they were reported from higher socioeconomic groups. No statistically significant association was observed between foetal malnutrition and the sex of the neonate in the present study. Similar observations were made by Faheem et al. and Adebami et al.[7,13] However, Almarzoki et al. reported a predominance of foetal malnutrition among female neonates.[12] This variation may be related to differences in population demographics, sample size, and regional biological variations. The absence of association in most studies suggests that foetal malnutrition is more strongly influenced by intrauterine environmental factors than by neonatal gender.

On comparison with BMI, PI and MAC/HC, the CAN score detected increased prevalence fetal malnutrition (p=<0.05). Previous Indian studies have reported similar findings as well.[13,17,20] The higher detection rate by the CAN score may be because it evaluates visible loss of subcutaneous fat and muscle wasting over multiple body areas rather than relying solely on body proportions. In contrast, Almarzoki et al. observed slightly higher proportion in detection of foetal malnutrition with BMI though it was not significant.[12] Using the CAN score as the reference standard, BMI demonstrated low sensitivity (32.46%) but relatively good specificity (78.38%) in detecting foetal malnutrition. Similar results were observed by Ezenwa et al., whereas Liladhar et al. and Almarzoki et al. reported higher sensitivity and lower specificity.[12,16,20] This difference may be attributed to the relatively smaller sample size in our study.

Among the routine anthropometric indices evaluated, the MAC/HC ratio demonstrated the highest diagnostic accuracy and specificity in detecting foetal malnutrition [Table 3]. This may be because mid-arm circumference reflects soft tissue and muscle mass depletion, while head circumference is relatively preserved during intrauterine nutritional deprivation due to the phenomenon of brain sparing. Weight for gestation showed very high specificity but poor sensitivity, indicating that many malnourished neonates may remain undetected if only birth weight criteria are used. Ponderal index demonstrated higher sensitivity but poor specificity, limiting its utility as a standalone screening tool.

Maternal comorbidities, particularly anemia, showed a significant association with foetal malnutrition in the present study. Similar findings were reported by multiple studies.[10,12,13,15-19] Reduced placental oxygen and nutrient delivery associated with maternal anemia may explain this association. Differences in prevalence of maternal comorbidities between populations may also contribute to varying incidences of foetal malnutrition across studies.

CONCLUSION

The CAN score is a simple, inexpensive, and reliable bedside tool for assessing neonatal nutritional status and facilitating early identification of foetal malnutrition, thereby enabling timely intervention and improving neonatal outcomes. Compared to conventional anthropometric indices, the CAN score was more effective in detecting occult foetal malnutrition, particularly among AGA neonates who

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may otherwise be overlooked. Among the anthropometric parameters studied, the MAC/HC ratio demonstrated the best overall diagnostic performance. However, as this was a cross-sectional study, follow-up of the study subjects to assess outcomes could not be performed. In addition, the CAN score is a subjective tool for assessing foetal malnutrition and may vary between observers. Nevertheless, the findings of the present study support the use of the CAN score as an effective standalone clinical method for detecting foetal malnutrition in term neonates.

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