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To Identify the Fetal Nutritional Status by Clinical Assessment of Newborn Using Can Score

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ABSTRACT

Fetal malnutrition (FM) is a clinical state, characterized by intrauterine loss of or failure to acquire normal amount of fat and muscle mass. Various terminologies used for describing intra uterine malnutrition includes small for gestational age (SGA), intra uterine growth restriction (IUGR) and placental insufficiency. CAN score is a scoring system based on nine 'superficial' readily detectable signs of malnutrition in the newborn baby. These includes clinically visible signs of nutritional status in hair, cheeks, neck, arms, chest, abdomen, back but tocks and legs, as developed to differentiate malnourished from appropriately nourished babies. Present study was a cross sectional, observational and analytical study, conducted in post-natal ward and NICU of department of Pediatrics of Peoples College of Medical Sciences & Research Centre, Bhopal during one and half year (1st December, 2018 to 31st may, 2020) of study period. ''To identify the fetal nutritional status by clinical assessment of newborn using CAN score''. Data was collected within 24-48 hrs of life of newborn (n = 411) after obtaining written consent from parents. Birth weight was recorded using digital electronic weighing machine, length was measured using infantometer, Head circumference, chest circumference and mid arm circumference was measured using non stretchable measuring tape. Proportionality indices like Kanawati Index (MAC/HC), PI and BMI was calculated for each new born baby and clinical assessment of new born using CAN score (based on superficial physical findings) was done for each newborn. Data was compiled using Microsoft Excel and analyzed using softwares SPSS® Version 20 and MED CALC 19.5. Male to female ratio was 1.12: 1. Fetal malnutrition (FM) was found in 18.5% babies as assessed by the CAN score of <25. Out of 411 babies, 76 (18.5%) were with FM (CAN score <25), 23 (5.6%) had MAC/HC ratio <0.25, 56 (13.6%) had Ponderal Index of <2.2, weight for GA was <10th centile in 36 (8.8%) and BMI was <10th centile in 51.09% babies. Weight for GA ($p<0.001$), MAC/HC ($p<0.001$), PI ($p<0.001$), BMI ($p<0.001$) and length for GA ($p<0.001$) all were found to have significant association in predicting the fetal malnutrition when CAN score of <25 was taken as the cut off value. Mean value of all anthropometric parameters i.e., birth weight, length, head circumference, chest circumference and mid arm circumference was significantly lower in those with FM as compared to those without FM ($p<0.001$). In present study, more babies are clustered between CAN score of 27-29. When modified CAN score cutoff of <27 was considered, 132 (32.1%) babies were found to be malnourished as compared to 76 (18.5%) babies with CAN score cutoff of <25. Also there is strong strength of association (p-value < 0.001) between modified CAN score cutoff of <27 and variables like weight for GA, PI, BMI and MAC/HC . With modified CAN score cutoff of <27, percentage of FM among AGA babies goes up from 12.26% to 26.66%. Based on the findings of present study it was found that CAN Score is a simple and systematic method to identify FM over and above those babies identified by commonly used anthropometric parameters like weight for GA, length for GA, MAC/HC, BMI and PI. CAN score is a simple method which does not require any sophisticated equipment or time-consuming calculations. Hence, CAN score can be used as an ideal method for screening malnourished babies in our community.

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Key Words
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INTRODUCTION

Fetal malnutrition (FM) is a clinical state, characterized by intrauterine loss of or failure to acquire normal amount of fat and muscle mass. This term was coined by Scott and Usher in 1963[1].

Assessment of fetal malnutrition should be included in the evaluation of all newborns regardless of the classification of their weight for gestational age (GA), as birth weight alone is a poor indicator of nutritional status at birth[2,3].

Various terminologies used for describing intra uterine malnutrition includes small for gestational age (SGA), intra uterine growth restriction (IUGR) and placental insufficiency. Although these terms are used synonymously with FM but both are quite different as they do not assess the accumulation of subcutaneous fat and muscle mass in the fetal body[2]. Also, they do not take account of genetic and ethnic variations amongst different populations[4].

It is important to recognize FM early in neonates as there is a high incidence of neonatal morbidity and mortality as well as long term neurological sequelae associated with it. Studies have shown that children with FM are more likely to have lower IQ scores, require higher need of special education, have neurologic disabilities, intellectual disabilities, learning disorders or seizures in late childhood as compared to children without FM[5,6].

The incidence of low birth weight (LBW) babies (<2500 g) continues to be high in India at about 18% in contrast to 5-7% in developed countries[7,8]. High incidence of LBW babies in India is due to the neglected health and education of females, teenage marriages and pregnancies, frequent pregnancies, maternal malnutrition, bad obstetric history, pregnancy induce hypertension (PIH), anemia and infections[9].

Nutritional status at birth can be assessed by using various anthropometric parameters [weight, length, head circumference (HC), chest circumference (CC), midarm circumference (MAC), proportionality indices [Body mass index (BMI), Ponderal index (PI), Kanawati Index (MAC/HC)] and Clinical Assessment of Nutritional status score (CAN score)[3,10,11].

CAN score is a scoring system based on nine 'superficial' readily detectable signs of malnutrition in the newborn baby. These includes clinically visible signs of nutritional status in hair, cheeks, neck, arms, chest, abdomen, back but tocks and legs, as developed to differentiate malnourished from appropriately nourished babies[2]. Researchers have reported that many newborn babies identified as malnourished by CAN score had been missed by using various other anthropometric parameters and indices[3,6,12-13].

Therefore, present study is undertaken to assess the utility of CAN score in identifying the FM in new born babies which would have been missed by using various anthropometric parameters alone or in combination.

Since neonatal morbidity and mortality is more closely related to nutritional status of newborn at birth than to the birth weight for gestational age alone. A simple, practical, clinically applicable scoring system Clinical Assessment of Nutritional Status Score (CAN score) was developed by Metcoff to differentiate malnutrition from appropriately nourished babies, irrespective of birth weight for any gestational age[2]. The score contains the examination for nine clinical signs viz. hair, cheeks, neck, arms, chest, skin of abdominal wall (or abdomen), back but tocks and legs. The score assesses nutritional status of the fetus at birth. Features of fetal malnutrition are sought for in each baby using nine 'superficial' readily detectable signs. Maximum score of 4 is awarded to each parameter with no evidence of malnutrition and lowest of 1 is awarded to parameter with the worst degree of malnutrition. The CAN score ranges between 9 (lowest) and 36 (highest). A baby with CAN score below 25 is regarded as having fetal malnutrition.

Aim: Present study was a cross sectional, observational and analytical study, conducted in post-natal ward and NICU of department of Pediatrics of Peoples College of Medical Sciences and Research Centre, Bhopal during one and half year (1st December, 2018 to 31st may, 2020) of study period. "To identify the fetal nutritional status by clinical assessment of newborn using CAN score".

Objectives:

- To assess fetal nutritional status by assessing newborn using CAN score
- To compare the assessment of fetal nutritional status using CAN score with selected anthropometric indices
- To assess the utility of CAN score to identify fetal malnutrition

Source of data: New born babies were recruited from People's Hospital, which is a allied hospital of Peoples College of Medical Sciences and Research Centre Bhopal, a tertiary referral Centre, getting patients from all socio-economic groups. A total of 411 new born babies were included in this study.

Inclusion criteria: All full-term (37 completed weeks of gestation) newborns as assessed by Modified Ballard score system.

Exclusion criteria:

- New-borns <37 completed weeks of gestation
- New-borns with congenital anomalies
- Babies born to mothers with Gestational Diabetes Mellitus

Sample size: All full term (37-42 weeks of gestational age) newborns delivered at People's Hospital, Bhopal during the study period were included in the study.

MATERIALS AND METHODS

Written consent (Annexure-III) was taken from parents before enrolling the babies in the study. Babies who fulfilled the exclusion criteria were excluded from the study. All babies were examined thoroughly as per pre-defined proforma (Annexure-II). Gestational age (GA) was assessed by using Modified Ballard scoring system, within first 24-48 hrs of life, babies who were found to be full term i.e., 37-42 weeks by Ballard scoring system were enrolled in the study.

Data was collected within 24-48 hrs of life of newborn (n = 411) after obtaining written consent from parents. Birth weight was recorded using digital electronic weighing machine, length was measured using infantometer, Head circumference, chest circumference and mid arm circumference was measured using non stretchable measuring tape. Proportionality indices like Kanawati Index (MAC/HC), PI and BMI was calculated for each new born baby and clinical assessment of new born using CAN score (based on superficial physical findings) was done for each newborn. Data was compiled using Microsoft Excel and analyzed using softwares SPSS® Version 20 and MED CALC 19.5.

CAN SCORE-CAN score of each baby was determined within first 24-48 hrs of life from nine superficially detectable signs of malnutrition; they are hair, cheeks, chin and neck, skin of forearm, skin of thigh and legs, back in scapular and interscapular region but tocks, chest and abdomen. Each sign is rated from 4 (best, no evidence of malnutrition) to 1 (worst, definite evidence of malnutrition). Total score ranges from 9 to 36. CAN score <25 is classified as fetal malnutrition (FM)[2]. In present study, CAN score was accepted as the gold standard for identification of fetal malnutrition and the various anthropometric indices were ssscompared to this gold standard (Fig. 1-3).

Figure 3 shows Gestational age (GA) assessment by new Ballard scoring system.

The distribution of babies into well nourished and malnourished groups using cutoffs of various anthropometric parameters, indices and CAN score.

CAN score	1	2	3	4
1. Hair	Straight "staring" hair with depigmented stripe (flag sign)	Still thinner, more straight, "staring" hair which does not respond to brushing	Thinner, some straight, "staring" hair	Large amount, smooth, silky, easily groomed
2. Cheek	significantly reduced bucal fat with narrow, flat face	Flat, poor or small pad of fat	Flat with good pad of fat	Full buccal pads and round face
3. Neck and Chin	No fat fold, neck with loose, wrinkled skin, very evident	some mandibular fat, minimal neck fat	Full mandibular fat, moderate neck fat, no rolls	Double or triple chin fat fold, neck not evident
4. Arms	sub cutaneous tissue minimal,skin very loose, easily grasped and pulled away from elbow	some sub cutaneous tissue present on upper and lower arm, pleats easily, can pick from elbow but not on back of hand and forearm	moderate sub cutaneous tissue present on upper and lower arm , slight pleating of skin, can not pick from elbow or back of hand and forearm	Full, round, cannot elicit "accordion" folds or lift folds of skin from elbow or tricep area
5. Legs	sub cutaneous tissue minimal, skin very loose, easily grasped and pulled away	some sub cutaneous tissue present, pleats easily	moderate sub cutaneous tissue present, slight pleating of skin	Full, round, cannot elicit folds or lift folds
6. Back	skin loose, easily lifted in a thin fold from the interscapular area	Flat (not full) but definite fat present	Round, less full, less firm	Difficult to grasp and lift skin in the interscapular area
7. Buttock	virtually no evident gluteal fat and skin of the buttocks and upper posterior high loose and deeply wrinkled	Skin upper medial thigh loose, skin easily picked up over anterior thigh but not over tibia and knee	Some subcutaneous tissue, can pick up easily but good turgor	Full round gluteal fat pads
8. Chest	progressively prominence of the ribs with obvious loss of intercostal tissues	Prominent ribs, some intercostals tissue	Intercostals space prominent, ribs obvious	Full, round, ribs not seen
9. Abdomen	distended or scaphoid, but with very loose skin, easily lifted,wrinkled	Scaphoid but not very loose skin, easily lifted and with some wrinkles	Round with loose skin, not easily lifted with no wrinkle	Full round with no loose skin

Fig. 1: Criteria and grading of can score

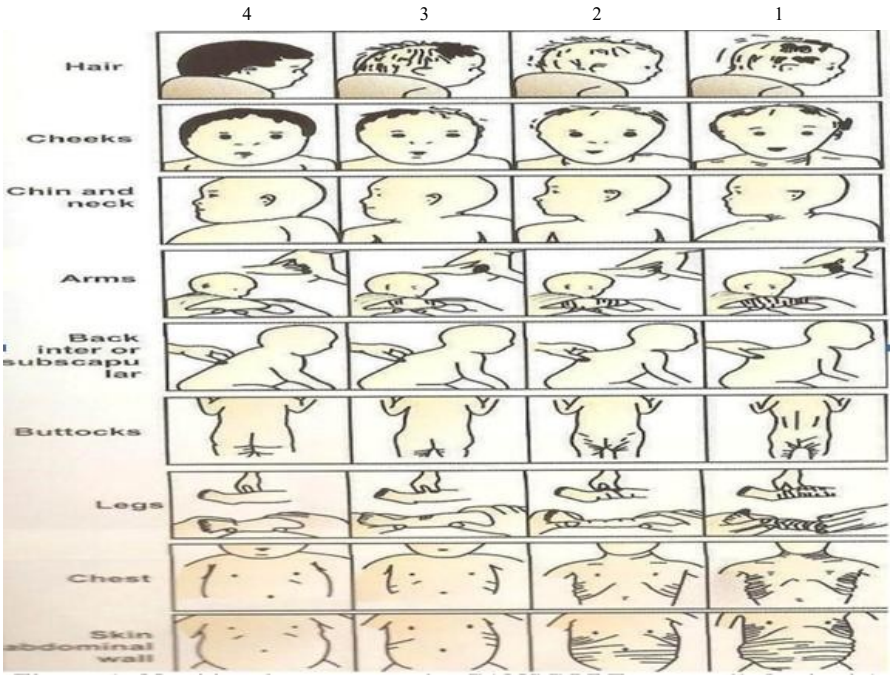

Fig. 2: Nutritional assessment by can score (1-9 criteria)

Neuromuscular Maturity

Score	–1	0	1	2	3	4	5
Posture							
Square window (wrist)	>90°	90°	60°	45°	30°	0°	
Arm recoil		180°	140–180°	110–140°	90–110°	<90°	
Popliteal angle	180°	160°	140°	120°	100°	90°	<90°
Scarf sign							
Heel to ear							

Physical Maturity

Skin	Sticky, friable, transparent	Gelatinous, red, translucent	Smooth, pink; visible veins	Superficial peeling and/or rash; few veins	Cracking, pale areas; rare veins	Parchment, deep cracking; no vessels	Leathery, cracked, wrinkled
Lanugo	None	Sparse	Abundant	Thinning	Bald areas	Mostly bald	
Plantar surface	Heel-toe 40–50 mm: –1 <40 mm: –2	>50 mm, no crease	Faint red marks	Anterior transverse crease only	Creases anterior 2/3	Creases over entire sole	
Breast	Imperceptible	Barely perceptible	Flat areola, no bud	Stippled areola, 1–2 mm bud	Raised areola, 3–4 mm bud	Full areola, 5–10 mm bud	
Eye/Ear	Lids fused loosely: –1 tightly: –2	Lids open; pinna flat; stays folded	Slightly curved pinna; soft; slow recoil	Well curved pinna; soft but ready recoil	Formed and firm, instant recoil	Thick cartilage, ear stiff	
Genitals (male)	Scrotum flat, smooth	Scrotum empty, faint rugae	Testes in upper canal, rare rugae	Testes descending, few rugae	Testes down, good rugae	Testes pendulous, deep rugae	
Genitals (female)	Clitoris prominent, labia flat	Clitoris prominent, small labia minora	Clitoris prominent, enlarging minora	Majora and minora equally prominent	Majora large, minora small	Majora cover clitoris and minora	

Maturity Rating

Score	Weeks
–10	20
–5	22
0	24
5	26
10	28
15	30
20	32
25	34
30	36
35	38
40	40
45	42
50	44

Fig. 3: New ballard score for gestational age assessment

Nutritional status of new born baby assessed by using CAN score is compared with other selected anthropometric indices like weight for GA, MAC/HC, PI, BMI and length for GA and are shown in Table 1. Different diagnostic values i.e sensitivity, specificity, predictive values (negative and positive) and likelihood

Table 1: Distribution of babies according to gender

Gender	Frequency	Percentage
Male	217	52.80
Female	194	47.20
Grand total	411	100.00

Table2: Anthropometric indicators of growth in study cohort (n = 411)

Variables	Mean	Standard deviation
Weight (g)	2774.25	405.780
Length (cm)	47.54	1.640
Head circumference (cm)	33.25	1.120
Chest Circumference (cm)	30.95	1.360
MAC (cm)	9.51	0.700
Kanawati Index (MAC/HC)	0.28	0.016
PI (g cm^{-3})	2.56	0.290
BMI (kg m^{-2})	12.20	1.400
CAN score	26.94	2.310

Table 3: Distribution of babies into well nourished and malnourished groups based on different parameters

Parameters		No of patients	Percentage
CAN score	<25	76	18.50
	≥25	335	81.50
	Total	411	100.00
MAC/HC	<0.25	23	5.60
	≥0.25	388	94.40
	Total	411	100.00
Ponderal index	<2.2	56	13.60
	≥2.2	355	86.40
	Total	411	100.00
Weight for GA	<10th centile	36	8.80
	≥10th centile	375	91.20
	Total	411	100.00
BMI	<10th centile	210	51.09
	≥10th centile	201	48.91
Length for GA	<10th centile	16	3.90
	≥10th centile	395	96.10
	Total	411	100.00

ratio (negative and positive) were determined for various anthropometric parameters taking CAN score as Gold standard (Table 2). Mean±SD of anthropometric parameters with and without fetal malnutrition is shown in Table 3. Association of FM with maternal risk factors is estimated (Table 4).

Frequency distribution graph between CAN score and no. of babies shows that more no. of babies were clustered between CAN score 27-29 (Fig. 2). Therefore, modified CAN score cutoff <27 to identify FM in our community is used and its comparison with CAN score cutoff <25 was done in assessing FM shown in Fig. 3, 4 and Table 5 and 6.

Male to female child ratio was 1.12: 1 in present study (Table 1).

Mean weight, length, head circumference, chest circumference, MAC, MAC/HC, PI, BMI and CAN Score is 2774.25 g, 47.54 cm, 33.25 cm, 30.95 cm, 9.51 cm, 0.28, 2.56 g cm^{-3}, 12.20 kg m^{-2} and 26.94, respectively (Table 2).

Table 3 and Fig. 4 shows that most commonly used anthropometric parameter, weight for gestational age identified 36 (8.8%) babies as malnourished, while BMI cutoff (<10th centile) could identify 210 (51.09%) babies as malnourished. CAN score (<25) used as gold standard in present study could identify 76 (18.5%) babies as malnourished.

We found strong association between all the variables with CAN Score cutoff of <25. Out of 411 babies, CAN score cutoff of<25 identified 76 (18.5%) as malnourished and 335 (81.5%) as well nourished. Weight for gestational age identified 36 (8.8 %) babies as SGA and 375 (91.2%) as AGA, 46 (12.3%) babies who were identified AGA by weight for gestational age were classified as malnourished by CAN score. MAC/HC ratio cutoff of<0.25 identified 23 (5.6%) babies as malnourished and 388 (94.4%) babies as well nourished; 55 (14.2%) babies who were identified as well nourished by MAC/HC ratio were classified as malnourished by CAN score. Ponderal Index cutoff of <2.2 identified 56 (13.6%) babies as malnourished and 355 (86.4%) babies as well nourished, 47 (13.2%) babies who were identified as well nourished by Ponderal Index were classified as malnourished by CAN score. BMI cutoff of <10th centile for GA identified 210 (51.09%) babies as malnourished and 201 (48.91%) as well nourished, 8 (3.9%) babies who were identified as well nourished by BMI found to be malnourished by CAN score. length for GA cutoff of <10th centile identified 16(3.9%) as malnourished and 395 (96.1%) as well-nourished, 64(16.2%) babies who were identified as well nourished by length for GA were identified as malnourished by CAN score. It was revealed that weight for GA ($p<0.001$), MAC/HC ($p<0.001$), Ponderal Index ($p<0.001$), BMI ($p<0.001$) and length for GA ($p<0.001$) were found to have significant association in predicting the fetal mal-nutrition when CAN score of <25 was taken as the cut off to identify FM (Table 4).

In present study nutritional status of new born babies were studied with various anthropometric parameters, proportionality indices and CAN score. Comparison of various parameters in identifying FM with CAN score (CAN score <25 in identifying FM taken as gold standard) was done. It was found that sensitivity was highest with BMI (89.5%) followed by MAC for age (46.4%), weight for GA (39.5%) and PI (38.2%). Specificity for FM was found to be highest with MAC/HC (99.6%) followed by length for GA (98.8%), HC for GA (98.8%), weight for GA (98.2%) and PI (91.9%). Specificity of BMI was found to be lower (57.6%) as compared to other parameters (Table 5).

In present study nutritional status of new born is assessed by CAN score and compared with selected anthropometric parameters. Comparison of mean±SD of anthropometric data of babies done with and without FM (as by CAN score cutoff of <25 as gold standard). It was found that birth weight, length, HC, CC and MAC all were significantly lower in those with FM as compared to those without FM ($p<0.001$). (Table 6).

Table: 4: Comparison of anthropometric parameters with and without FM with CAN score cutoff of <25

		CAN score			
		FM (<25)	Without FM (≥25)	Total	p-value
Weight for GA	<10 centile	30 (83.4%)	6 (16.6%)	36 (8.8%)	<0.001
	≥10th centile	46 (12.3%)	329 (87.7%)	375 (91.2%)	
	Total	76 (18.5%)	335 (81.5%)	411 (100%)	
MAC/HC	<0.25	21 (91.4%)	2 (8.6%)	23 (5.6%)	<0.001
	≥0.25	55 (14.2%)	333 (85.8%)	388 (94.4%)	
	Total	76 (18.5%)	335 (81.5%)	411 (100%)	
Ponderal index	<2.2	29 (51.7%)	27 (48.3%)	56 (13.6%)	<0.001
	≥2.2	47 (13.2%)	308 (86.8%)	355 (86.4%)	
	Total	76 (18.5%)	335 (81.5%)	411 (100%)	
BMI	< 10th centile	68 (32.4%)	142 (67.4%)	210 (51.09%)	<0.001
	≥10th centile	8 (3.9%)	193 (96.1%)	201 (48.91%)	
	Total	76 (18.5%)	335 (81.5%)	411 (100%)	
Length for GA	<10th centile	12 (75%)	4 (25%)	16 (3.9%)	<0.001
	≥10th centile	64 (16.2%)	331(83.8%)	395(96.1%)	
	Total	76 (18.5%)	335(81.5%)	411 (100%)	

Table 5: Comparison of various parameters in identifying FM with CAN score cutoff of <25

Parameters	Weight for GA	PI	MAC/HC	BMI	Length for GA	HC for GA	MAC for GA
Sensitivity	39.50	38.20	16.20	89.5	15.80	11.80	46.40
Specificity	98.20	91.90	99.60	57.6	98.80	98.80	97.70
PPV	83.30	51.80	88.30	32.5	75.00	69.20	87.40
NPV	87.70	86.80	83.40	96.0	83.80	83.20	92.30
LR	81.95	38.42	19.24	61.8	25.57	16.71	18.55

Table 6: Comparison of mean±SD of anthropometric data of babies with and without FM

	CAN score		
Parameters	With FM (<25)	Without FM (>25)	p-value
Birth weight (g)	2325.53±274.40	2870.90±358.46	<0.001
Length (cm)	46.29±1.85	47.85±1.46	<0.001
Head circumference (cm)	32.04±1.04	33.50±0.98	<0.001
Chest circumference (cm)	29.76±1.47	31.24±1.18	<0.001
MAC (cm)	8.89±0.56	9.67±0.57	<0.001

Table 7: Comparing maternal risk factors in babies with and without FM

Maternal risk factors		With FM (CAN score <25)	Without FM (CAN score ≥25)	p-value
Birth spacing (years)	<3	27	108	0.090
	≥3	14	103	
	Primi	35	124	
BMI of mother	<18.5	0	2	0.164
	18.5-25	40	131	
	25-30	28	163	
	>30	8	39	
PIH	Absent	41	299	<0.001
	Present	35	36	
Hypothyroid	Absent	60	264	0.978
	Present	16	71	
Socio-economic status	Upper	0	10	0.003
	Upper middle	9	95	
	Lower middle	50	193	
	Upper lower	16	36	
	Lower	1	1	
Anemia	Absent	57	305	0.001
	Mild	10	15	
	Moderate	8	14	
	Severe	1	1	
Maternal infection	Absent	26	259	<0.001
	Present	50	76	

In present study maternal risk factors were identified in each new born baby and compared in babies with and without FM. We found significant association between presence of PIH, anemia, infection and poor socioeconomic status of mother with FM. Whereas risk factors such as birth spacing (year), BMI of mother and hypothyroidism has got no association with FM (Table 7).

Figure 5 shows frequency distribution curve between CAN score and number of babies for each score. It shows initial steady but slow rise upto CAN score 26, followed by steep linear increase in number of babies from CAN score 27, maximum number of babies (113) at CAN score 28 and then there is fall in frequency. This graph indicates that majority of babies are clustered between 27-29 score. With the assumption that in a community large proportion of babies cannot be abnormal, we also calculated association of all anthropometric parameters with CAN score <27 as cutoff for FM. When CAN score <27 was taken as modified cutoff to identify FM, it detected more malnourished babies which were missed by using CAN score cutoff of <25 (Fig. 5).

Table 8 shows Comparison of anthropometric parameters with and without FM (FM is defined here as CAN score <27). When modified CAN score Cutoff

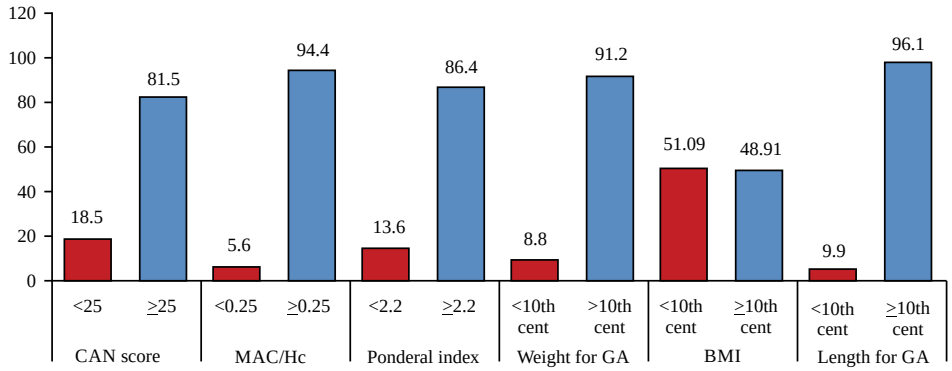

Fig 4: Distribution of babies into well nourished and malnourished groups using cut-offs of various parameters

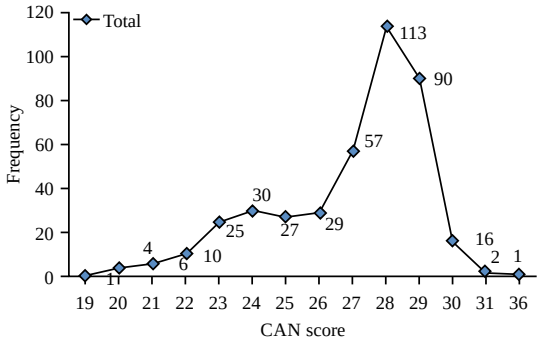

Fig 4: Frequency distribution curve between CAN score and number of babies for each score

Table 8: Comparing anthropometric parameters with and without FM (FM is defined by modified CAN score cutoff of <27)

		CAN score			
		FM (<27)	Without FM (>27)	Total	p-value
Weight for GA	<10 cent	32 (88.9%)	4 (11.1%)	36 (8.8%)	<0.001
	> 10th cent	100 (26.7%)	275 (73.3%)	375 (91.2%)	
	Total	132 (32.1%)	279 (67.9%)	411 (100%)	
MAC/HC	<0.25	22 (95.7%)	1 (4.3%)	23 (5.6%)	<0.001
	≥ 0.25	110 (28.4%)	278 (71.6%)	388 (94.4%)	
	Total	132 (32.1%)	279 (67.9%)	411 (100%)	
Ponderal index	<2.2	38 (67.9%)	18 (32.1%)	56 (13.6%)	<0.001
	≥2.2	94 (26.5%)	261 (73.5%)	355 (86.4%)	
	Total	132 (32.1%)	279 (67.9%)	411 (100%)	
BMI	< 10th cent	112 (53.3%)	98 (46.7%)	210 (51.1%)	<0.001
	>10th cent	20 (9.95%)	181 (90.05%)	201 (48.9%)	
	Total	132 (32.1%)	279 (67.9%)	411 (100%)	

was considered, 132 (32.5%) babies were found to be malnourished as compared to 76 (18.5%) babies with cutoff of <25. Analysis shows a strong strength of association (p-value< 0.001) between modified CAN score cutoff of <27 and various anthropometric variables (weight for gestational age, PI, BMI and MAC/HC).

This comparative table and figure Shows the number of AGA and SGA babies based on weight for gestational age criteria as well as number of malnourished babies identified by both the cutoff values of CAN score (<25 and <27), the table shows that the proportion of FM goes up to 32.11% from 18.5% by modifying the cutoff value of CAN Score from <25 to <27. Percentage of FM babies among AGA babies goes up from 12.26% to 26.66% when cutoff of CAN score was shifted from <25 to <27 (Table 9).

The utility of CAN Score in classifying newborn babies with and without FM in comparison to other anthropometric parameters was analysed by using Receiver Operating Characteristic curve (ROC cure) and Area Under Curve (AUC) analysis.

Taking the CAN score as gold standard for identifying the fetal malnutrition (FM), we draw the ROC and calculated AUC for various anthropometric parameters and indices. Since birth weight with cut off 2300 g has maximum AUC than other variables, it is a better marker for predicting FM. The identification of FM with birth weight <2300 g had a sensitivity of

Table 9: Identification of FM by using CAN score cutoff of <25 and <27

	CAN score cutoff <25	CAN score cutoff <27
Total no of AGA babies	375 (91.2%)	375 (91.2%)
Total no of SGA babies	36 (8.8%)	36 (8.8%)
Total no of FM babies	76 (18.5%)	132 (32.11%)
Total no of FM among AGA	46 (12.26%)	100 (26.66%)
Total no of FM among SGA	30 (83.33%)	32 (88.88 %)

Table 10: ROC-AUC curve of various anthropometric variables in comparison to CAN score cutoff <25

Variables	No.	Optimal criteria cutoff	Sensitivity	Specificity	+LR	-LR	+PV	-PV	AUC	p-value
Birth weight (g)	411	>2300	95.52	61.84	2.5	0.077	91.7	75.8	0.891	<0.001
MAC (cm)	411	>8.5	97.31	47.37	1.85	0.057	89.1	80.0	0.855	<0.001
BMI (kg m^{-2})	411	>10.57	95.5	44.74	1.73	0.10	88.3	69.4	0.837	<0.001
PI (g cm^{-3})	411	>2.02	99.7	11.84	1.13	0.025	83.3	90.0	0.761	<0.001
Length (cm)	411	>45.5	97.31	28.95	1.37	0.093	85.8	71.0	0.749	<0.001
MAC/HC	411	>0.258	99.4	10.53	1.11	0.057	83.0	80.0	0.714	<0.001

95.52%, which means that 95.52% of FM can be detected by birth weight measurement and a specificity of 61.84% means that there is a 61.84% improbability of well nourished in newborns who have a birth weight <2300 grams. Likewise, we can interpret for other parameters also (Table 10).

DISCUSSIONS

Present study is aimed to assess the nutritional status of new born using CAN score and compare it with other selected anthropometric indices. It concludes that the CAN score can identify FM with greater efficacy and can detect FM in babies who are missed by other commonly used methods of nutritional assessment.

In a study by Deodhar *et al*.[8] FM was identified in 19.6% babies using CAN score cutoff of <25, out of this, 84.2% babies were SGA and 12.9% babies were AGA as per weight for gestational age criteria[9]. Kashyap observed that CAN score identified FM in 27.4% babies and among these babies, 8.3% were classified as AGA by weight for gestational age criteria. Also, 11.35% babies who were classified as well nourished by PI ($\geq$2.2 g cm^{-3}) were found to be malnourished by CAN score. Similar results were obtained by many investigators[3,12,13]. Similarly, in present study CAN score identified FM in 18.5% babies whereas weight for GA criteria identified 8.8% babies as SGA and 91.2% as AGA, 12.3% babies who were identified as AGA, were found to be malnourished by CAN score.

Present study observed 18.5% babies to be malnourished by using CAN score and 13.6% by PI which is less than observed by Abhay kumar Dhanorkar (32.29 and 24.48%, respectively).

To classify nutritional status of new born, PI has been used by various investigators[14]. PI relies on the principle that length is spared at the expense of weight during period of acute conditions; whereas, weight and length velocities are proportionately impaired in chronic insults. Therefore, using PI alone as a method of nutritional assessment can misclassify the babies. The other drawback of PI is that any error in calculating length is cubed in the calculation of PI[14].

Many cities now have multi-ethnic population and application of weight standard alone may be inappropriate in studying nutritional status. To overcome this problem, many investigators Meadows *et al*. 1986, Man Mohan *et al*. studied MAC/HC ratio in identifying nutritional status and concluded that this ratio shows no intra ethnic variation and can be used as screening test for identifying babies whose growth is retarded, even when their weight does not fall below 10th centile. However, in chronic in-utero insult, head circumference is also reduced because of proportionate growth retardation; therefore, such babies are missed by MAC/HC ratio. Similarly, babies with hydrocephalus may give falsely low reading even when they are normally nourished. CAN score can identify FM in these babies too who are missed by PI and MAC/HC ratio[4,14].

In a study by Ezenwa the nutritional status of full term new born baby was done using CAN score and compared it with PI, BMI and MAC/HC. FM was identified in 14.5, 10.3, 13.1 and 2.8% of babies using CAN score, PI, BMI and MAC/HC ratio respectively. Out of FM babies identified by CAN score, PI, MAC/HC and BMI identified FM in 19.5, 12.3 and 53.7% babies respectively which shows that BMI was most sensitive anthropometric index for detecting FM. In present study CAN score identified FM in 18.5% babies whereas MAC/HC, PI, weight for gestational age, BMI and length for gestational age identified FM in 5.6, 13.6, 8.8, 51.09 and 4.4% newborn babies respectively. Out of FM identified by CAN score, MAC/HC, PI, weight for gestational age, length for gestational age and BMI identified FM in 16.2, 38.2, 39.2, 15.8 and 89.5% new born babies, respectively. Thus, present study also shows that BMI has maximum sensitivity in identifying FM.

In present study we assessed the FM by preparing Receiver Operating Characteristic curve (ROC curve) and Area Under Curve (AUC). The ROC-AUC analysis showed that AUC for birth weight, MAC, BMI, PI, length and MAC/HC for determining FM was 0.891, 0.855, 0.837, 0.761, 0.749 and 0.714, respectively with a p-<0.001. AUC was highest for birth weight followed

by MAC and BMI. This highlight that all these three parameters have higher sensitivity in determining FM (p<0.001). similarly a study done by Sen observed that AUC for birth weight (0.796, 95% CI 0.741-0.850) followed by MAC (AUC 0.776, 95% CI 0.721-0.831) can be considered to be the best surrogate anthropometric measures of low birth weight. However, they have not used the CAN score as a measure of FM in their study. This highlights that birth weight and BMI are strongly associated with FM, however if coupled with CAN score can provide better assessment for FM.

In a study done by Ajay mohan, assessment of nutritional status of new born was done using CAN score cutoff of <25 as well as <21 along with other anthropometric parameters. In this study more number of babies were clustered between 21 and 24, so they have taken modified CAN score cutoff as <21. On the contrary, in present study large number of babies were clustered between 27 to 29 CAN score, so we selected <27 as modified cutoff score. The explanation behind considering this modified cutoff is that in a community large proportion of babies cannot be called as abnormal. In present study, on using modified CAN score cutoff <27, the percentage of FM went up from 18.5-32.11%. This signifies that when we are using modified CAN score cutoff of <27, we are able to detect more malnourished newborn than using cutoff of <25.

In present study, maternal infections were found to have significant association with FM. Similar association was also seen in studies done by other investigators[15]. They observed that HIV, malaria, periapical infection, urinary tract infection, vaginal trichomoniasis, placental malaria and severe chorio-amnionitis all can affect the fetal growth.

Maternal infection leads to loss of appetite, nausea and vomiting which further decrease mother's dietary intake. Maternal infections can also elicit a systemic inflammation that can restrict foetal growth through reduction in placental vascularization and diminished nutrient or oxygen transfer to fetus.

LIMITATIONS OF THE STUDY

Being a hospital based and single centered study, it is difficult to extrapolate the results found in large community. In present study, observations were done by single observer only. Therefore, inter-observer variations could not be calculated.

Strength of the study:

- Sufficiently large sample size that includes neonates belonging to all socio-economic strata was the main strength of this study

The study was done in the department of Pediatrics of People's College of Medical Sciences and Research Centre, Bhopal after obtaining clearance from was Research Advisory Committee and Institutional ethical committee. Exhaustive literature review was conducted to get important and relevant information concerning fetal malnutrition and its clinical assessment using CAN score and other anthropometric methods for appropriate study design development and implementation.

The results can be summarized under following points:

- The mean value of weight, length, head circumference, chest circumference, MAC, MAC/HC, PI, BMI and CAN Score in subjects included in present study was 2774.25 g, 47.54 cm, 33.25 cm, 30.95 cm, 9.51 cm, 0.28, 2.56 g cm^{-3}, 12.20 kg m^{-2} and 26.94, respectively
- Male to female ratio was 1.12: 1
- Fetal malnutrition (FM) was found in 18.5% babies as assessed by the CAN score of <25
- Out of 411 babies, 76 (18.5%) were with FM (CAN score <25), 23 (5.6%) had MAC/HC ratio <0.25, 56 (13.6%) had Ponderal Index of <2.2, weight for GA was <10th centile in 36 (8.8%) and BMI was <10th centile in 51.09% babies
- Weight for GA (p<0.001), MAC/HC (p<0.001), PI (p<0.001), BMI (p<0.001) and length for GA (P<0.001) all were found to have significant association in predicting the fetal malnutrition when CAN score of <25 was taken as the cut off value
- Comparison of various parameters with CAN score (<25 taken as gold standard) showed that sensitivity was highest with BMI (89.5%) followed by MAC for age (46.4%), weight for GA (39.5%) and PI (38.2%). Specificity was highest with MAC/HC (99.6%) followed by length for GA (98.8%), HC for GA (98.8%), weight for GA (98.2%) and PI (91.9%). Specificity of BMI was found to be minimum (57.6%) as compared to other parameters
- Mean value of all anthropometric parameters i.e., birth weight, length, head circumference, chest circumference and mid arm circumference was significantly lower in those with FM as compared to those without FM (p<0.001)
- Maternal risk factors such as PIH, aneamia, maternal infection and poor socioeconomic status have significant association with FM, whereas birth spacing (year), BMI of mother and hypothyroidism were not significantly associated with the presence of FM
- In present study, more babies are clustered between CAN score of 27-29

- Therefore we took modified CAN score cutoff of <27 and calculated its association with other anthropometric parameters
- When modified CAN score cutoff of <27 was considered, 132 (32.1%) babies were found to be malnourished as compared to 76 (18.5%) babies with CAN score cutoff of < 25. Also there is strong strength of association (p<0.001) between modified CAN score cutoff of <27 and variables like weight for GA, PI, BMI and MAC/HC
- With modified CAN score cutoff of <27, percentage of FM among AGA babies goes up from 12.26-26.66%

The area under the curve (AUC) for the birth weight (0.891), MAC (0.855), BMI (0.837), PI (0.761), length (0.749) and MUAC/HC (0.714) with p<0.001 was observed. AUC was highest for birth weight followed by MAC and BMI. This highlight that all these three parameters have good sensitivity and specificity for identifying FM (p<0.001).

CONCLUSION

Fetal malnutrition (FM) is a major problem in developing countries like India as compared to developed countries. FM is a clinical state defined by intrauterine loss or failure to acquire normal amount of subcutaneous fat and muscle mass and is independent of birth weight and gestational age. Various methods are used for assessment of nutritional status of new born but each method has its own limitations. Based on the findings of present study it was found that CAN Score is a simple and systematic method to identify FM over and above those babies identified by commonly used anthropometric parameters like weight for GA, length for GA, MAC/HC, BMI and PI. CAN score is a simple method which does not require any sophisticated equipment or time-consuming calculations. Hence, CAN score can be used as an ideal method for screening malnourished babies in our community.

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