Clinical assessment of nutritional status in neonate (CANS score) in diagnosis of fetal malnutrition in comparison with standard anthropometry

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Abstract

Background: Fetal malnutrition (FM) is a clinical condition resulting from failure of the fetus to acquire adequate amounts of subcutaneous fat and muscle mass during its intrauterine life, with short and long term implications.

Aim of the work: As the diagnosis of FM is essentially clinical, the aim of this study is to estimate the prevalence of FM using the Clinical Assessment of Nutritional Status (CANS) score & comparing the results with the classic anthropometric parameters and investigate FM impacts on early neonatal morbidities.

subjects and methods: This is a cross-sectional study of full-term and preterm infants that was done between January 2023 and January 2024 (*n* = 385) at **Alhussein neonatal intensive care unit & gynecology and obstetric department** Early neonatal morbidities e.g hypoglycemia , polycythemia , Neonatal sepsis, RDS, feeding intolerance and hyperbilirubinemia were detected within the first week of life for the studied population who required NICU admission. The CANS score was evaluated for all infants enrolled in the study within 48 hours of birth. Moreover the standard anthropometric measure e.g. Body mass index (BMI), Ponderal Index (PI), and Mid-Upper-Arm Circumference/Head Circumference ratio (MUAC/HC) were calculated &both results were compared .

Results: the FM cutoff values of CANS score <25, BMI <11.2 kg/m^2, PI <2.2 g/cm^3 and MUAC/HC < 0.27. that show significant difference between CANS & standard method in assessment of FM . the prevalence rate of FM for the studied population was Using the CANS score **36.4%**, BMI **31.4%** , MUAC/HC **23.4%** and PI **22.3%**

Conclusions:

The CANS score allows a better identification of nutritional status of infants than using the standard anthropometric parameters.

Key words: Fetal Malnutrition, Clinical Assessment of Nutritional Status score, Anthropometric Parameters**.**

Introduction:

Fetal malnutrition (FM) which describes the underweight/wasting seen in newborns is a significant contributor to perinatal morbidity and mortality and requires proper documentation (Adebami *et al.*, 2007).

Fetal malnutrition has been implicated in both short- and long-term consequences among children and adults, characterized by an increased risk of cardiovascular diseases and insulin resistance. The incidences of perinatal hypoxia including related morbidities and late neurodevelopmental problems have been reported to be higher among infants with fetal malnutrition. Psychometric studies revealed that children with fetal malnutrition were more likely to have lower Intelligence Quotient (IQ) scores, required special education, intellectual disorder, and learning disability among late childhood compared to children without fetal malnutrition (Tesfa, et al 2021) . The clinical state of (FM) may be present at almost any birth weight. (Ezenwa *et al.*, 2016)

Globally, the incidence of FM is between 2% and 10% of total births with highest incidence in developing countries. A study conducted in Nigeria 2007 , reported an incidence of 18.8% for FM in term newborns.(Adebami *et al.*, 2007)

The incidence of fetal malnutrition was 12.32 % in Ethiopia reported by (Sume et al 2023). In UAE incidence FM was 4% reported by (Cheikh Ismail et al 2020)

in Egypt neonatal mortality rate was 10 deaths per 1,000 live births In 2021 (Sharrow et al 2022).(WHO world bank) . The assessment of the nutritional status of the fetus has been of considerable interest to clinicians because of its potential serious sequelae on multiple organ systems manifesting as perinatal problems and/or long-term central nervous system sequelae. Recent studies have also demonstrated the evidence that FM may have a far-reaching effect on adult life such as susceptibility to cardiovascular disease and non-insulin dependent diabetes mellitus. (Hernandez *et al.,* 2020)(Kuiper-Makris et al 2021) Various anthropometric indices have been used to identify babies that suffered suboptimal fetal growth (weight, length, mid-arm circumference (MAC) and head circumference (HC), proportionality indices (ponderal index [PI], MAC/HC ratio, body mass index [BMI]) and Clinical Assessment of Nutritional (CAN) status and its score. (Martínez-Nadal et al 2016).

CAN score contains nine clinical signs, namely, hair, cheeks, neck, arms, chest, abdomen, back, buttocks, and legs to differentiate malnourished from appropriately nourished babies that developed by (Metcoff 1994)

In some of details its a Systematized inspection and estimation of loss of SC tissues and muscles of nine superficial physical parameters including hair and buccal fat in the cheeks, chin and neck, arms, back (interscapular and subscapular skin), buttocks, legs, chest, and abdominal wall skin. These signs will be rated from 1 (worst, severe FM) to 4 (best, well nourished). The highest and lowest total CANS scores are 36 and 9, respectively. A total score of <25 is considered as FM. Therefore the CANS score can serve as a simple clinical index for identifying FM and for the prediction of neonatal morbidity associated with it, without the aid of any sophisticated equipment (*Dhanorkar et al., 2014a*).

Many factors affect fetal growth, including the nutritional state and social habits /status (e.g. smoking, literacy level) of the mother, the state of placental function and the genetic makeup of the fetus (Ezenwa *et al.*, 2013). Poor maternal nutrition during pregnancy (as in Egypt) has been shown to lead to adverse birth outcomes and long-term negative consequences. (Gresham *et al.*, 214).

The aim of this study is to:

1. Identify the prevalence of FM in newborns.
2. Compare the CANS score with various anthropometric and proportionality methods in assessing FM.
3. Identify the effects of FM on early neonatal morbidities (as hypoglycemia, polycythemia and neonatal sepsis).

Ethical considerations and informed consent:

1. A written informed consent was obtained from parents or the legal guardians before the study
2. An approved by the local ethical committee was obtained before the study.
3. The authors declared no potential conflicts of interest with respect to the research ,authorship and/or publication of this article.
4. All the data of the patients and results of the study are confidential &the patients have the right to keep it.
5. The patient has the right to withdraw from the study at any time.

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Sample size equation :

The sample size was calculated using the G.POWER Statistics program2022 that included a total population of 385 neonate .

Inclusion Criteria

Neonates of both genders,
Gestational age (Full term & Pre term)
Singleton pregnancies.

Exclusion Criteria

- Presence of major congenital malformations (can affect measurement of anthropometric indices) or stigmata of chromosomal anomalies
- Severe perinatal asphyxia /neonatal illness (measurements may be too stressful for already sick neonate.
- Age at assessment > 48 hours (post-delivery weight loss is higher).
- UN cooperative parents
- Multiple pregnancies

methodology

This is **A cross-sectional** study that included a total population of 385 birth, singleton neonates with gestational ages between 28-41 weeks. The data from these neonates was collected between January 2023 and January 2024 at **AL Hussein university hospital**. A subgroup of the targeted population included those neonates which required NICU admission.

Study procedures

All the studied neonate were subjected to the following

History taking

Maternal History : including Maternal age (in years) ⋆, Parity: The number of pregnancies⋆, Mode of delivery (NVD or CS) ⋆,Premature rupture of membranes ⋆,Antibiotics intake in case of PROM ⋆,Antenatal corticosteroid treatment for preterm pregnancies ≤ 35 weeks ⋆, Maternal illnesses eg : Preeclampsia ⋆,Eclampsia ⋆,Gestational DM ⋆,Antiphospholipid syndrome, Anemia⋆, Maternal dietary protein intake ≥ 3 times per week ⋆,Vitamins and minerals supplementation during pregnancy.

Neonatal History : including That including Gestational age in week using first day of last menstrual period and new Ballard score Ballard et al 1991 ★, first cry ★,birth weight in kg ★, head circumference in cm ★, length in cm ★, neonate need NICU admission.

Assessment of Fetal Malnutrition

Weight will be recorded classify to appropriate for gestational age(AGA) , small for gestational age(SGA) and large for gestational age(LGA) (Oslen et al 2010). ⋆,The HC will be measured using a flexible non stretchable tape⋆, The MAC will be measured using the same tape at the midpoint between the acromion and the olecranon process with the forearm flexed at 90° at the elbow.⋆,BMI will be calculated for each baby weight (kg) / length^2 (m^2). BMI <11.2 kg/m^2 is considered as FM⋆, The MAC/HC ratio: <0.27 is considered as FM .⋆,Ponderal Index (PI): This will be computed from the formula: PI = weight (g) / length3 (cm) X100. A PI <2.2 was considered as malnutrition.
Clinical assessment of nutritional status (CANS) will be assessed for all babies at first 48h of life this consisted of inspection and estimation of loss of subcutaneous tissues and muscles in the designated areas. Hair, cheeks, neck and chin, arms, back, buttocks, legs, chest and abdomen and scored it from 1 the lowest to 4 the highest total score < 25 will be diagnosed as fetal malnutrition (Metcoff 1994)(Adebami OJ 2007) (*Martinez-Nadal et al., 2016*).

Detection of Early Neonatal Morbidities

These morbidities were detected within the first week of life of the neonate needing for NICU admission e.g. Hypoglycemia, Polycythemia, Respiratory Distress Syndrome, Neonatal sepsis ,Hyperbilirubinemia , Feeding intolerance

Results and statically analysis

Table (1) Baseline characteristics of the studied neonates:

Items	Values (no=385) No	%
Gestational age (weeks): **Mean ±SD** **Median (min-max)**	 37.98 ±2.31 38 (29-41)	
Pre-term < 37 w **Full term ≥ 37 w**	59 326	15.3% 84.7%
Sex : **Males** **Females**	 192 193	 49.9% 50.1%
Mode of delivery: **NVD** **CS**	 55 330	 14.3% 85.7%

This table showes the basic characteristic of studied newborn .

Table (2) Nutritional assessment of the studied neonates by standard anthropometry.

Items	Values (no=385) No	%
Weight (Kg) **Mean ±SD** **median(min-max)** **Nourished ≥ 10th percentile*** **Malnourished<10th percentile**	 2.8 (3.1-4.1) 2.8±0.6 290 95	 75.3% 24.6%
Length (cm) **Mean ±SD** **median(min-max)** **Nourished ≥ 10th percentile*** **Malnourished<10th percentile***	 48(40-52) 48.2±2.4 294 91	 76.3% 23.6%
H.C (cm) **Mean ±SD** **median(min-max)** **Nourished ≥ 10th percentile***	 34(27-37) 33.7±1.5 300 85	 77.9% 22.1%

Malnourished<10th percentile		
MAC (cm) **Mean ±SD** **median(min-max)**	9.71±1.46 9.5(5.5-13)	
MAC/HC ratio **Mean ±SD** **Median (min-max)**	0.28±0.04 0.28(0.17-0.37)	
Nourished **Malnourished**	295 90	76.6% 23.4%
BMI **Mean ±SD** **Median (min-max)**	11.82±1.91 12.0(5.90-16.20)	
Nourished ≥ 11.2 **Malnourished < 11.2**	121 264	68.6% 31.4 %
Ponderal index **Mean ±SD** **Median (min-max)**	2.41±0.36 2.40(0.21-3.40)	
Nourished **Malnourished**	299 86	77.7% 22.3 %
Weight for age **AGA** **LGA** **SGA**	 289 1 95	 75.1% 0.3% 24.7%

*percentile According to Fenton growth chart

This table showed that the prevalence of neonatal malnutrition by MAC/HC was 23.4%, by BMI was 31.4%, by Ponderal index was 22.3%, . There was only one case his weight was large for gestational age, 75.1% of their weight was appropriate for gestational age, and 24.7% of their weight was small for gestational age.

Table (3) Nutritional assessment of the studied neonates by CANS score

CANS **Mean ±SD** **Median (min-max)**	 **22.76±4.47** **28 (15- 36.00)**	
Nourished	No (243)	63.1 %
Malnourished	No (142)	36.9 %

This table showed that the prevalence of neonatal malnutrition by CAN score was 36.4%.

Table (4) Early neonatal morbidity of the studied neonates:

Items	Values (no=385) No	%
NICU admission	107	27.8%
Hypoglycemia	22	5.7%
Polycythemia	9	2.3%
RDS	50	13.0%
Neon. sepsis	50	13.0%
hyperbilirubinemia	36	9.4%
Feeding intolerance	29	7.5%

This table showed that 27.8% of cases underwent NICU admission after being malnourished, 5.7% had hypoglycemia, 2.3% had polycythemia, 13% had RDS, 13% had neonatal sepsis, 9.4% had hyperbilirubinemia, and 7.5% were intolerant to feeding.

Table (5) comparison of nutritional status of new born by CAN score and standard anthropometry In preterm neonate No (59) .

	Nourished	Malnourished	P-value
MAC/HC	21 (35.6%)	38 (64.4%)	0.004*
BMI	19 (32.2%)	40 (67.8%)	<0.001*
PI	25 (42.4%)	34 (57.6%)	0.011*
CAN SCORE	17 (28.8%)	42 (71.2%)	0.030*

*p-value is significant

This table showed that there is a significant difference between nourished & malnourished in pre term neonate that detected by all methods .

Table (6) comparison of nutritional status of new born by CAN score and standard anthropometry In full term neonate No (326).

	Nourished	Malnourished	P-value
MAC/HC	274 (84%)	29(55.8%) 23(44.2%)	**0.195**
BMI	245 (75.2%)	81 (24.8%)	0.029*
PI	310 (95 %)	52 (16%)	**0.226**
CAN SCORE	226 (69.3%)	100 (30.7%)	0.016*

*p-value is significant

This table showed that there is a significant difference between nourished & malnourished in full term neonate that detected by BMI and CAN score .

Table (7) Multivariable binary logistic regression analysis for prediction of risk factors associated with the malnutrition detected by CANS score:

Independent variables	P-value	OR	95% C.I.for OR	
			Lower	Upper
Male gender	0.958	1.019	.504	2.061
Prematurity	0.002*	4.624	1.767	12.103
NVD	0.069	2.307	.937	5.681
Maternal age <20 years 20-34	 .002 0.105	 0.156 .302	 .047 .071	.514 1.287
Multipara	0.220	1.719	.723	4.085
PROM >12 hour	0.287	1.877	.589	5.987
Antibiotic for PROM	0.163	2.930	.646	13.293
Ante natal corticosteroid	0.839	1.306	.099	17.214
Preeclampsia	0.058	.070	.004	1.097
Eclampsia	0.999	.000	.000	.
Gestational D.M	0.225	5.887	.336	103.288

Antiphospholipid s	0.998	.000	.000	.
Anemia	<0.001*	4.609	2.373	8.952
Ptn >3time/week	0.905	.940	.343	2.579
Maternal Vitamin minerals	<0.001*	.052	.018	.147

*P-value is significant OR=odds ratio CI=confidence interval

This table showed that after plotting all risk factors, either maternal or fetal, we found that prematurity increased the probability of malnutrition detected by can score by more than 4.6 times. Maternal anemia also increased the probability of malnutrition detected by can score by about 4.6 times, while the administration of vitamins and minerals by the mother during pregnancy decreased the probability of malnutrition to about two-thirds (0.948). In addition the younger maternal age less than 20 years decreased the probability of malnutrition by 0.844.

Table (8) Sensitivity, specificity, positive predictive value and negative predictive value of BMI, MAC/HC ratio , ponderal index and CAN score in detection of malnutrition referenced by CAN score:

Items	BMI	MAC/HC ratio	ponderal index	CANS
Sensitivity	83.1%	58.5%	59.2%	87.7%
Specificity	98.8%	97.1%	99.2%	98.9%
Ppv	97.5%	92.2%	97.7%	98%
Npv	90.9%	80.0%	80.6%	90%

Main result of our study :

- CAN score was capture most cases of fetal malnutrition é 36.4% if compared with other classic proportionally indices as BMI, , MUAC/HC and PI 31.4% , 23.4% and 22.3%. respectively.
- Fetal malnutrition recorded by only weight when fenton growth chart was used equal 24.7% less than percentage recorded by CAN score .
- Incidence of fetal malnutrition was recorded by CANS score and other proportionally indices more in preterm than full-term neonate.
- Most cases of malnutrition was recorded in cases classified as small for gestational age.
- Some cases of fetal malnutrition was recorded by CAN score and other proportionally indices in neonate classified as adequate for gestational age which mean weight only is not enough to detect fetal malnutrition.
- Neonatal sepsis and respiratory distress more common morbidities in

neonate with malnutrition and admitted in NICU .

- Prematurity , maternal anemia , premature rupture of membrane more than 12 hour , increase the incidence and risk of fetal malnutrition .
- Administration of maternal multivitamin prenatal and Nataly , protein diet more than 3 time per week decrease the incidence and risk of fetal malnutrition
- Body mass index (BMI) is the best indices to detect fetal malnutrition after CANS score which has Sensitivity 83.1% and specificity 98.8% .

Discussion

Our study was performed to assess the prevalence of neonatal malnutrition using CANSCORE compared with standard anthropometry. Our findings reveal that the frequency of FM was 23.4% when assessed by MAC/HC, 31.4% using BMI, 22.3% with the Ponderal index, and 36.4% through CANSCORE. This finding matches the general trend in literature where CANSCORE is the gold standard tool in detecting cases of FM.

Several studies have measured the prevalence of malnutrition in the population using some or all of these indices. In contrast to our findings, **Bolaji et al**. reported lower prevalence rates for all indices: PI at 16.6%, MAC/HC at 14.5%, and CANSCORE at 23.3%. but the CANSCORE was the test that captured the majority of cases of malnutrition. Similarly, **Tiwari et al**. reported a lower prevalence using CANSCORE at 20.1%, PI at 12%, BMI at 20.9%, and MAC/HC at 18.9% (Tiwari et al., 2018). Our study indicates a lower prevalence of malnutrition using CANSCORE at 36.4% compared to **Chelli, S. B. et al**.'s finding of 41.5%. However, our Ponderal Index's malnutrition detection rate is higher at 22.3% compared to their 14%. While **Chelli, S. B. et al**. demonstrated a low sensitivity of 19.27% for PI, our study showed a higher sensitivity for PI at 22.3%. Despite these differences, both studies agree on the significance of CANSCORE as a more sensitive tool for identifying malnutrition than the Ponderal Index (Chelli et al., 2022). Both our study and **P S, T., et al. (2015)** assessed the importance of CANSCORE in identifying malnutrition, with our study showing a prevalence of 36.4% and **P S, T., et al**. showing 26.17%. Our BMI estimated of FM at 31.4% closely aligns with their findings of 39.45% but MAC/HC identified 34.38% of cases as having FM contrary to our result of 23.4%. However, our Ponderal Index has a lower detection rate at 22.3% compared to their 23.44% (P S et al., 2015). These differences may be attributed to the fact that these studies were undertaken in different countries and timings, and a more thorough analysis of the chronological and geographic effects is needed to reach the full picture.

Studying the preterm subgroup, we found that CANSCORE could identify 71.2% of cases as malnourished followed by BMI (67.8%), MAC/HC (64.4%), and Ponderal index (57.6%). In a comparison of malnutrition prevalence among preterm babies, **Ezenwa, et al. (2016)** found that CANSCORE identified 34.3% of preterm infants as having fetal malnutrition (FM). This was closely followed by the Ponderal Index (PI) at 30.7%, MAC/HC at 12.1%, and birth weight at 3.6%. The study highlighted that while all anthropometric parameters had high specificity in detecting FM, they exhibited low sensitivity. This indicates that while these measures are effective in ruling out those without malnutrition, they might not be as efficient in identifying cases of malnutrition. Overall, the study underscores the prevalence of FM, particularly among preterm babies, with CANSCORE showing a higher detection rate of malnourished subjects compared to anthropometric measurements (Ezenwa et al., 2016). A similar conclusion was asserted by **Lin et al**. who emphasized that a combination of BMI and CANS had a detection rate of 99.3% in full-term infants and 100% in preterm infants. This result was better than using individual methods or other combinations (Lin et al., 2020).

Regarding the diagnostic accuracy of different indices, we compared all indices to CANSCORE, which is the gold standard for FM detection in the literature. BMI demonstrated a sensitivity of 83.1% and specificity of 98.8%. The MAC/HC ratio showed a sensitivity of 58.5% and specificity of 97.1%. The Ponderal Index had a sensitivity of 59.2% but a high specificity of 99.2%. Taking into account our finding that the BMI can capture more cases of FM and the 83.1% sensitivity when referenced by CANSCORE, we suggest that these indices are detecting two populations of FM. Results from the literature are in favor of CANSCORE which was able to capture most cases of FM in past studies. In comparison with **Bolaji et al**.'s findings, the MAC/HC ratio in our study had a comparable sensitivity (58.5% vs. 48%) and slight higher specificity (97.1% vs. 96%). The Ponderal Index from our study presented a higher sensitivity (59.2% vs. 53%) and a similar specificity (99.2% vs. 95%) compared to Bolaji et al.'s results (Bolaji et al., 2016). According to Tiwari et al.'s findings, BMI showed higher sensitivity (75.7% vs. 51.4%) to the Ponderal Index. The MAC/HC ratio from our study exhibited a slightly higher sensitivity (58.5% vs. 42.9%) but had a slightly lower specificity (84.4% vs. 87.1%) (Tiwari et al., 2018). Moreover, when we compared our results to P S et al. findings, our study's BMI had a higher sensitivity (83.1% vs. 80.6%) and specificity (98.8% vs. 74.6%). The MAC/HC ratio from our research demonstrated a slightly better sensitivity (58.5% vs. 55.22%) and a comparable specificity (84.4% vs. 73.02%). Our study's Ponderal Index presented a marginally higher sensitivity (59.2% vs. 58.2%) and a considerably higher specificity (99.2% vs. 88.8%) (P S et al., 2015).

We explored both maternal and fetal risk factors that may be able to predict FM then checked how these correlations vary across CANS SCORE. we found that prematurity CANSCORE: [OR: 4.6]) and maternal anemia CANSCORE: [OR: 2.4]) were significantly associated with a higher risk of FM in the offspring across. Moreover, maternal intake of vitamins and minerals CANSCORE: [OR: 0.02]) was associated with a lower incidence of FM.

The effect of gestational age was evident in our results. In malnourished cases, we observed 61 cases of SGA and 39 cases of AGA. Conversely, in well-nourished cases, we had 19 cases of SGA, 206 cases of AGA, and one case of LGA. This difference in the distribution of cases with SGA between both subgroups reached statistical significance. Subsequently, our study showed that FM is associated with many serious perinatal problems. The results demonstrated that FM was significantly associated with NICU admission, hypoglycemia, polycythemia, RDS, neonatal sepsis, hyperbilirubinemia, and feeding intolerance.

LIMITATIONS

The most important limitation of this study was a lack of cooperation on behalf of some of the parents despite the tact of the research team and their specialized opinions. Consequently, the implementation of the plan in all the phases was minimized.

Conclusion

Our study assessed neonatal malnutrition using CANSCORE and anthropometric measures. CANSCORE was able to identify most cases with FM in both term and preterm newborns. Significant predictors of fetal malnutrition included prematurity and maternal anemia. Maternal vitamin and mineral intake were protective. We emphasize CANSCORE's sensitivity, however, a combination of BMI and CANSCORE may be able to detect the majority of FM cases in preterm neonates as reported by multiple studies in the literature. Furthermore, our study demonstrated prematurity and maternal anemia as pivotal predictors of FM across the evaluated indices. Conversely, maternal intake of essential vitamins and minerals emerged as a protective factor against FM. While variables like maternal age, protein intake, and parity correlated sometimes with FM, factors such as mode of delivery and certain maternal conditions did not achieve statistical significance.

Finally CAN score may be a simple clinical index for identifying fetal malnutrition and for prediction of neonatal morbidity associated with it, without the aid of any sophisticated equipment .

Recommendation

This study has a small sample size in one center and hence larger multicentric studies are required to validate this screening tool for identifying fetal malnutrition.

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