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MID-UPPER ARM, CHEST AND HEAD CIRCUMFERENCE CUT-OFF POINTS AND EQUATIONS FOR IDENTIFYING LOW BIRTH WEIGHT IN EGYPT

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Abstract: Because of the prevalent resource-poor settings during deliveries in developing countries, few anthropometric surrogates have been suggested to identify low birth weight (LBW < 2500 grams) babies. The WHO reported that validity of mid-upper-arm circumference (MUAC) and chest circumference (CHC) as well as its cut-off points for identifying LBW babies varied across the nations and ethnic groups. This study was conducted to identify the anthropometric cut-off points suitable for detecting LBW in Egypt. A prospective cross-sectional study including 129 full term newborns was carried out. Thirteen percent newborns were found LBW. Birth weight, length, MUAC, CHC and head circumference (HC) were recorded. MUAC, CHC and HC were found to be highly correlated with the birth weight. The best correlation observed was between birth weight and MUAC ($r = 0.673$, $P < 0.001$). The best discriminator of LBW, as detected by receiver operating characteristic (ROC) curve, was the MUAC. This study showed that birth weight = - 433.880 + (331.706 MUAC). The MUAC cut-off point value of < 9 cm had the highest sensitivity and specificity for identifying LBW, followed by the CHC < 31 cm and lastly the HC < 32 cm. Linear regression models evoked the following 3-anthropometeric-component equation as the most predictive mean for birth weight calculation: "Birth Weight = 199.507 MUAC+ 77.633 HC + 61.446 CHC – 3610.071".

Keywords: low birth weight; anthropometry; mid-upper-arm circumference; chest circumference; head circumference; Egypt.

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INTRODUCTION

Ninety eight percent of the neonatal annual 4 million deaths take place in developing countries mostly at home where initial care is carried out by relatives, and traditional birth attendants [World Health Organization, 1996]. Only half of the newborns are weighed at birth and for a smaller proportion of them gestational age is known [Blanc and Wardlaw, 2005]. One-sixth of newborns are low birth weight (LBW < 2500 grams) that represents the most important risk factor for neonatal deaths [Lawn et al., 2005; World Health Organization, 2001]. Moreover, LBW babies who survive the critical neonatal period may suffer impaired physical and mental growth. Therefore, an early identification and prompt referral of LBW newborns is primordial to reduce neonatal morbidity and mortality.

In resource-poor settings, many of deliveries take place at home and birth-weight is most often not recorded. Therefore, there is a need to develop simple, inexpensive and practical methods to identify LBW newborns soon after birth [Mullany et al., 2006]. Recent studies from developing countries have suggested different anthropometric surrogates to identify LBW babies and have recommended various cut-off values for identification of LBW babies [Ahmed et al., 2000; Arisoy and Sarman, 1995; Das et al., 2005; Dhar et al., 2002; Ezeaka et al., 2003; Gupta et al., 1996; Hossain et al., 1994; Naik et al., 2003; Samal and Swain, 2001; Verma et al., 1996]. A multi-center study carried out by the World Health Organization (WHO) reported that validity of mid-upper-arm circumference (MUAC) and chest circumference (CHC) as well as its cut-off points for identifying LBW babies varied across the nations and ethnic groups [WHO, 1993]. This paper aims to determine the cut-off points of the MUAC, CHC and head circumference (HC) and build up a practical LBW calculating equation.

MATERIAL AND METHOD

A prospective cross-sectional study including all consecutive full-term, singleton, live born babies at Al- Mataria Teaching Hospital was carried out. The newborns with congenital anomalies and gestational age of less than 37 weeks (preterm babies) were excluded. Informed consent was obtained from the mothers to examine their newborn within the 24 hours after birth. Newborns were weighed. Circumferences of head, chest, mid-upper-arm and body length were measured to the nearest 0.1 cm using a non-elastic, flexible, fiber glass measuring tape according standard techniques described by Jelliffe, 1966. MUAC was measured at the midpoint between the tip of acromion process and olecranon process of the left upper arm. HC was measured between glabella anteriorly and along the most prominent point posteriorly. CHC was measured at the level of nipple at the end phase of expiration.

Statistical analysis was conducted using the SPSS version 10 program of personal computer. The student's t-test compared the data mean values. Pearson Correlations were calculated to evaluate the relationship between the variables. P-values were two-tailed and values <0.05 were considered statistically significant. Non-parametric receiver operating characteristic (ROC) curve analyses were carried out to calculate 95% confidence intervals of areas under the curve (AUC). ROC curves were used to evaluate the accuracy of different measures to identify the LBW babies. The larger the AUC, the more representative the case is. Sensitivity (the ability of the test to detect those who are truly diseased or true positive rate), specificity (the ability of the test to detect those who are free of disease or true negative rate) and positive predictive value (the percentage of true positive to all positive by the examined test) were calculated at cut-points for all measures. The optimum cut-point was chosen as the point with the highest [(sensitivity + specificity)/2] ratio; it corresponds to the lowest total misclassification error rate. Linear regression (stepwise method) models were performed to predict factors affecting birth weight.

RESULTS

During the study period, a total of 129 full term newborns (70 females and 59 males) constituted the material to work on. Their anthropometric measures including birth weight, length, MUAC, CHC and HC are shown in Table 1. Seventeen of the 129 (13.2%) newborns were LBW newborns. Measures in males and females did not statistically differ. The MUAC, CHC and HC were highly correlated with the birth weight ($P < 0.001$) (Figure 1). The best correlation coefficient observed was that for the weight / MUAC association ($r = 0.673$, $P < 0.001$) (Table 2). The best discriminator of LBW, as detected by ROC-AUC, was the MUAC (AUC = 0.827) followed by the HC (AUC = 0.343), and lastly the CHC (AUC = 0.256) (Figure 2).

The MUAC < 9 cm had the highest sensitivity, specificity and positive predictive values for identifying neonates with a birth weight < 2500 gram, followed by the CHC < 31 cm and lastly the HC < 32 cm. These cut-off points correspond to 70.6% sensitivity for MUAC, 58.8% for CHC and 58.8% for HC. They correspond to 97.3% specificity

Table 1 Descriptive statistics of birth weight and anthropometric measurements

	Total (n=129)	Female (n=70)	Male (n=59)	P-value (Female/male)
Birth weight (grams)	3123.60 ±641.01	3136.36 ±552.18	3108.47 ±737.32	.946 (NS)
Length (centimeters)	49.446 ±3.139	49.679 ±2.596	49.169 ±3.687	.543 (NS)
Mid-upper-arm circumference (centimeters)	10.725 ±1.3	10.893 ±1.239	10.525 ±1.353	.312 (NS)
Chest circumference (centimeters)	32.758 ±2.457	32.860 ±2.103	32.637 ±2.834	.738 (NS)
Head circumference (centimeters)	33.248 ±1.931	33.479 ±1.883	32.975 ±1.966	.325 (NS)

NS= Non-significant

Table 2 Correlation between birth weight and anthropometric measurements

	Mid-upper-arm circumference	*Chest Circumference*	*Head Circumference*
Birth weight	.673**	.637**	.590**

** Correlation is significant at the 0.001 level.

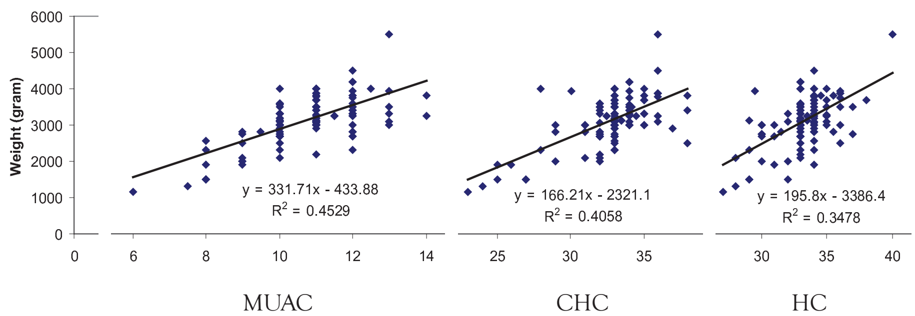

Figure 1 Correlation between newborn birth-weight and MUAC, CHC & HC

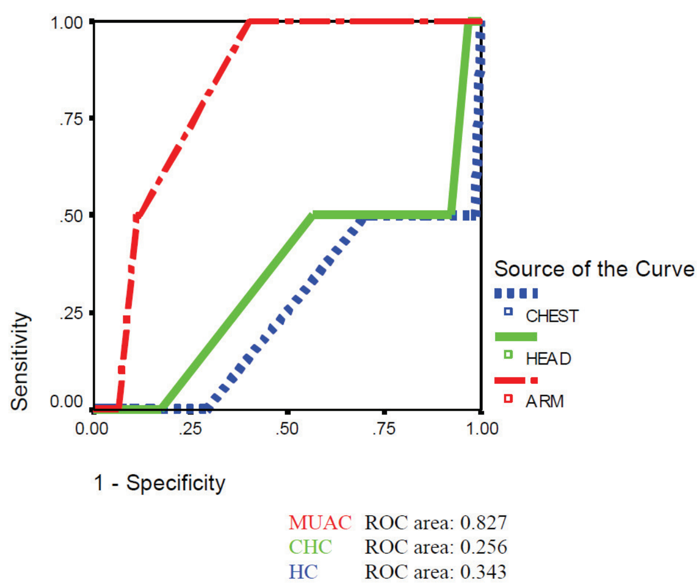

Figure 2 Comparison of ROC curves for MUAC, CHC and HC to choose optimal surrogate for birth weight

Table 3 Validity of mid-upper-arm, chest and head circumferences to identify LBW newborns

	Critical limit (Centimeters)	*Sensitivity*	*Specificity*	*Positive Predictive Value*
Mid-upper-arm circumference	9	70.6%	97.3%	80
Chest Circumference	31	58.8%	92.9%	55.6
Head Circumference	32	58.8%	89.3%	45.5

Table 4 Linear regression (stepwise method) models of birth weight in relation to anthropometric measures

Model	*Predictors*	*Coefficient (b1)*	*Std. Error*	*t*	*P-value*	*R*	*R Square*	*Adjusted R Square*
1	Constant	-433.880	349.488	-1.241	.217	.673	.453	.449
	MUAC	331.706	32.352	10.253	.000			
2	Constant	-3193.528	673.180	-4.744	.000	.731	.534	.526
	MUAC	247.780	34.943	7.091	.000			
	HC	110.074	23.539	4.676	.000			
3	Constant	-3610.071	673.704	-5.359	.000	.749	.560	.550
	MUAC	199.507	38.344	5.203	.000			
	HC	77.633	25.817	3.007	.003			
	CHC	61.446	22.390	2.744	.007			

Dependent Variable: Birth Weight (BW)

Birth Weight = - 433.880 + (331.706 MUAC)
Birth Weight = - 3193.528 + (247.780 MUAC + 110.074 HC)
Birth Weight = - 3610.071 + (199.507 MUAC + 77.633 HC + 61.446 CHC)

for MUAC, 92.9% for CHC and 89.3% for HC (Table 3).

Linear regression test (stepwise method) models to predict the correlation between birth weight and anthropometric measures was performed (Table 4). It resulted in the following 3 linear equations:

Birth Weight = - 433.880 + (331.706 MUAC)
Birth Weight = - 3193.528 + (247.780 MUAC + 110.074 HC)
Birth Weight = - 3610.071 + (199.507 MUAC + 77.633 HC + 61.446 CHC)

It evoked the 3-anthropometeric-component equation as the most predictive formula for birth weight calculation.

DISCUSSION

In developing countries birth weight is often not recorded due to lack of weighing scales [WHO, 1993]. Identifying LBW babies can reduce neonatal morbidity and mortality. WHO reported LBW raising incidence in Egyptian urban as 1.6% in 1992 and 12% in 2008[El- Zanaty and Ann, 2001 & 2009]. An incidence of 12.1% was reported on a large urban and rural scale in Egypt in 2002 [Mansour et al., 2002]. LBW represented 13.2% in the current study.

Literature shows recommendations to use CHC, MUAC and HC as anthropometric surrogates to identify LBW babies [Ahmed et al., 2000; Arisoy and Sarman, 1995; Das et al., 2005; Dhar et al., 2002; Ezeaka et al., 2003; Hossain et al., 1994; Verma et al., 1996] in developing countries. Very close to the current result that determines MUAC < 9 cm as an ideal cut-off point in urban Egyptian society, in 1994, MUAC < 9.5 cm was proposed for the rural Egyptian LBW neonates [Hossain et al., 1994]. Unlike an earlier report in rural Egyptian communities [Diamond et al., 1991], the CHC shows as a better indicator for LBW than the MUAC. MUAC is a good indicator for birth weight and reflects the nutritional condition [Ahmed et al., 2000; Arisoy and Sarman, 1995; Das et al., 2005; Gibson, 1990; Hossain et al., 1994; Sasanow, 1986; Sreeramareddy et al., 2008; 2009]. MUAC linear regression curve and equation in the current study show stronger values than CHC and HC. HC has been argued as inaccurate due to the high liability of head moulding during birth especially during prolonged and obstructed labor [Dhar et al., 2002]. Moreover, calculating birth weight using MUAC is -needless to say- a simpler way than the 3-component equation that takes MUAC, CHC and HC all in consideration.

The present study limitations include low number of LBW newborns since only full-term births were considered. Consequently the positive predictive values were not high. Preterm and multiple pregnancies were excluded because these newborns can be either appropriate for gestational age or small for date. All measures were recorded by the same investigator to reduce bias. Generalizing results to the community may be cautiously considered since this study was carried out on a sample elevated from a hospital during a short period. Poor precision (nearest 50 grams) of spring type of weighing scale used in the study was another limitation.

CONCLUSION

MUAC with a cut-off point of < 9 cm may be considered the optimal anthropometric surrogate to identify Egyptian LBW.

BIOGRAPHY

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