International Journal of Contemporary Pediatrics
Jose P et al. Int J Contemp Pediatr. 2017 Nov;4(6):2120-2125
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291
DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20174743

Original Research Article

Is head to chest circumference ratio a better detector of macrosomia in infants of diabetic mothers as compared to birth weight >4000g?

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Received: 18 August 2017
Accepted: 16 September 2017

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ABSTRACT

Background: In populations with a high incidence of low birth weight, a macrosomia index (ratio of head /chest circumference) may better detect infants of diabetic mothers rather than a birth weight of ≥4000g. The objective of this study was to correlate Macrosomia Index ≤1 (MI) with maternal HbA1c at delivery.
Methods: Prospective cross-sectional study in a Medical College Hospital in South India from November 2012 to March 2014. Study subjects were 715 term consecutive, mother/neonate pairs, booked, inborn and singleton deliveries. Birth weight, head and chest circumference of neonates, and maternal HbA1c at delivery were measured. The calculated macrosmia index (MI) was correlated with maternal HbA1c. Pearson correlation and odd's ratio were calculated.
Results: Of 715 mothers, 68.3% (488/715) had HbA1c >5.4% (range 4.2 to 10.5%), although only 32.7% (234/715) were categorized as gestational diabetics in pregnancy. Odds of Macrosomia Index ≤1 in neonates with maternal HbA1c > 5.4% was 7 times (95%CI: 3.2-15.4) as compared to that of neonates of mothers with HbA1c ≤ 5.4 ($p<0.001$). 13.4% (96/715) of neonates had MI ≤1 but only 1.4% (10/715) had birth weight of ≥4000g.
Conclusions: MI ≤1 correlated with an HbA1c of >5.4% at delivery. Hence, in addition to birth weight ≥4000g, MI ≤1 should also be used to detect macrosomia in infants of diabetic mothers.

Keywords: Chest circumference ratio, Infant of diabetic mother, Macrosomia index

INTRODUCTION

Birth weight cut-off criteria varying from ≥4000g, ≥4250g or even ≥4500g has been traditionally used to define macrosomia, though no particular consensus exists. Proportions of macrosomia as defined by birth weight vary in different populations from 3.2% to 20% and within populations of the same country.[1-4] Macrosomia is also a consistent consequence of maternal gestational diabetes mellitus (GDM), and its severity is proportional to glycemic levels of the mother.[1,5] The incidence of GDM in the US has increased by 122% between 1989 and 2004.[6] Seshiah et al in a community based study estimated a GDM prevalence of 17.8%, 13.8% and 9.9% among urban, semi-urban and rural population in South India.[7] Another hospital based study from South India reported a prevalence of 23.3% but noted that 61.2% (158/458) of women had at least one abnormal blood glucose value in oral glucose tolerance test (OGTT) whereas Gopalakrishnan et al found a prevalence of 41.9 % in North India.[8,9] As per the National Family Health Survey (NFHS-4, 2014-2015) female obesity is second highest in India amongst women of Puducherry (37.1%) with Tamil Nadu following close behind at 30.9%. Incidence of high blood sugar amongst women was found to be fourth highest in Puducherry.[10]

One of the most devastating complications of GDM is neonatal hypoglycemia.[6,2] As birth weight is also a function of genetics and maternal constitution, the question arises as to how useful is birth weight alone as a marker for macrosomia in infants of diabetic mothers in developing countries. Some health-care providers have used growth appropriate charts to detect babies over 90th percentile for birth weight, and found these charts to be more useful for predicting neonates who end up requiring care as compared to using a cut off of ≥4000g birth weight.[2,12] Others have used Ponderal index to detect macrosomia.[13] Increase in chest circumference in utero in response to maternal hyperglycemia results in a lower head to chest circumference ratio (HC:CC) and may be a better detector of macrosomia due to maternal diabetes as compared to birth weight.[14] Workers have found that the HC:CC ratio of the newborn is reversed in maternal diabetes and has a linear relationship with fasting blood glucose.[15]

In the absence of universal screening for maternal diabetes in developing countries, a high prevalence of low birth weight, low prevalence of large for gestational age babies, and lack of availability of accurate birth weight, we propose that an abnormal macrosomia index or MI (HC in cm/CC in cm) of ≤1 should be considered as a marker for macrosomia in infants of diabetic mothers, irrespective of maternal GDM status and birth weight.

The senior author of this paper had repeatedly observed that often babies of non-GDM mothers, admitted to the neonatal unit, presented with disproportionate macrosomia, hypoglycemia, polycythemia, and even persistent pulmonary hypertension of newborn. Most of these babies were <4000g at birth. When a post-natal HbA1c was performed on these mothers, almost all were >5.4%. These observations seemed to suggest that one OGTT at 24-28 weeks might be insufficient to detect GDM, hence the reason for this study.

METHODS

This study was carried out in a Medical College Hospital in Puducherry, in South India, from October 2012 to March 2014. The aim was to determine the relationship between the proposed macrosomia index and maternal HbA1c at labour. Institutional Research and Ethics committee approval were obtained prior to collection of data.

Inclusion criteria

- Term, singleton babies
- Inborn

Exclusion criteria

- Proven overt diabetes in mother
- Head circumference <3rd or >90th percentile at birth
- Major congenital anomalies, detected by antenatal ultrasound or postnatal examination.

All babies were weighed on an electronic scale (Phoenix Medical Systems Pvt Ltd, Chennai) with an accuracy of 10g, within one hour of birth. Head and chest circumference were measured by non-stretchable tape. Head circumference was measured along the supraorbital region and above ears and occipital prominence. Chest circumference was taken along the inter-mammary line. Both head and chest circumference were taken within 2 hours of birth and expressed in centimeters.

Our premise of macrosomia in infants of diabetic mothers is a normal head with a bigger body; hence we proposed the macrosomia index as the ratio of head circumference to chest circumference ≤1.[14]

All mothers had been classified as GDM or non-GDM based on oral glucose tolerance test values done either at 24-28 weeks or 32 weeks of gestation following the International Association of the Diabetes and Pregnancy Study Groups criteria (IADPSGC).[16]

HbA1c was done at the time of blood drawing when mothers were admitted for delivery, irrespective of GDM status. HbA1c was determined by the particle enhanced immune-turbometric method on a semi auto-analyzer (Merck Microlab 200) using the HbA1c Diassys reagent. HbA1c values ≤5.4% was considered normal.[17]

Statistical analysis

Data was entered in Microsoft excel and analyzed using SPSS for windows software version 17.0. Descriptive statistics used were mean and standard deviation for continuous variables and percentages for dichotomous/categorical variables. Pearson's correlation was used to test the relationship between continuous variables. Test of association used were independent sample t test and chi square test. The measure of association used in the study was Odds ratio with precision estimates (95% confidence interval).

RESULTS

A total of 715 mother-infant pairs were enrolled the study. The baseline maternal and neonatal characteristics of mother-infant pairs were compared with respect to HbA1c at delivery and are shown in Table 1.

The mean HbA1c at delivery ranged from 4.2 to 10.5 % among the entire study sample. It was surprising to observe nearly 68.3% (488/715) of neonates were born to mothers with HbA1c >5.4%, although only 32.7% (234/715) of mothers had been assigned GDM status after initial OGTT. The mean birth weight of neonates was 3007.3±417.7 grams (1400-4400 g), and Macrosomia Index (MI) was 1.06±0.04 (0.94-1.15).

Macrosomia incidence using traditional definition of >4000g, was found only in 1.4% (10/715) in this study. But macrosomia as defined by abnormal MI (≤1) was 13.4% (96/715).

Table 1: Maternal and neonatal characteristics.

Baseline characteristics		HbA1c at labour		
		Normal ≤5.4% n = 227 (31.7%)	Abnormal >5.4% n = 488 (68.3%)	P value
Maternal				
Age (yrs)		24.45±2.61	24.24±2.56	0.301
GA at delivery (weeks)		38.74±0.99	38.87±1.03	0.214
Parity	Primi	109 (48%)	223 (45.7%)	0.562
	Multiparous	118 (52%)	265 (54.3%)	
Mode of delivery	Normal	125 (55.1%)	286 (58.6%)	0.527
	Cesarean	93 (41%)	179 (36.7%)	
	Instrumental	9 (3.9%)	23 (4.7%)	
GDM status	Non-GDM (481, 62.3%)	173 (76.2%)	308 (63.1%)	0.000
	GDM (234, 32.7%)	54 (23.8%)	180 (36.9%)	
Neonatal				
Gender	Male	108 (47.6%)	227 (46.5%)	0.557
	Female	119 (52.4%)	261 (53.5%)	
Growth	SGA	52 (22.9%)	64 (13.1%)	0.928
	AGA	174 (76.7%)	417 (85.5%)	
	LGA	1 (0.4%)	7 (1.4%)	
Anthropometry	Birthweight (g)	2915±432.36	3049.84±404.09	0.040
	Head circumference (cm)	33.9±1.24	34.08±1.18	0.513
	Chest circumference (cm)	31.68±1.26	32.52±1.37	0.000
Macrosomia Index	≤1	7 (3.1%)	89 (18.2%)	0.000
	>1	220 (96.9%)	399 (81.8%)	
	Mean (SD)	1.05±0.03	1.07±0.04	

Among mothers with HbA1c >5.4% nearly one-fifth, 18.2% (89/488) delivered babies with abnormal macrosomic index (MI≤1). There was statistically significant moderate negative correlation between HbA1c at labour and MI ($r = -0.4221$; $p < 0.001$).

The odds of having abnormal MI in term neonates born to mothers with HbA1c >5.4% was observed to be 7 times (95% C.I: 3.2-15.4) the odds of having abnormal MI in term neonates born to mothers with HbA1c at labour ≤5.4% and is statistically significant (p value<0.001). This statistically significant association between HbA1c at labour and MI was observed in both known GDM (OR: 11.8; 95% C.I: 1.6-88.1) and non-GDM group (OR: 6.3; 95%C.I: 2.6-14.8). Among the GDM mothers there was a statistically significant difference between normal and abnormal HbA1c levels at labour (p <0.0001), perhaps suggesting many mothers had poorly controlled diabetes in spite of early diagnosis (Table 1).

The odds of having abnormal HbA1c in mothers with GDM was observed to be only 1.8 times (95% C.I:1.27-2.58) the odds of having abnormal HbA1c in non-GDM mothers. This weak association is due to the fact that there were many mothers with high HbA1c levels among the non-GDM, which was a surprising finding of this study. Incidence of abnormal MI in the GDM group was 14.1% (33/234) and among the non-GDM group 13.1% (63/481) which was not statistically significant.

There were only 10 babies weighing >4000g, one among GDM and 9 among non-GDM mothers. This clearly shows that applying traditional definition of macrosomia picked up only 0.4% (1/234) babies whereas abnormal MI was seen in 14.1% (33/234).

DISCUSSION

Researchers have tried to use surrogate markers such as head to chest circumference, head to midarm circumference, Ponderal index, or weight above 90th centile for detecting macrosomia.[12,14,18,19] In a study by Nasrat et al, it was seen that head circumference showed no change but only truncal fat deposition occurred in fetuses of GDM mothers.[20]

Infants of well controlled GDM mothers showed no difference in anthropometry as compared to non-GDM

mothers.[21] Also Dhar et al showed chest circumference is one indicator that can be measured by health-care providers with minimal inter-observer variability.[22] Head and chest circumference are the most reliable measures for inter and intra-examiner variability, mid-arm circumference, and length the least reliable.[23,24] Since Indian medical, nursing and paramedical personnel are well versed in measuring head and chest circumference, a ratio of head to chest circumference of ≤1 could be used as a surrogate marker for macrosomia (Macrosomia Index, MI).

Other health-care providers have also found that reversal of ratio of head and chest circumferences better reflects the effect of maternal metabolism on the fetus and could be important in predicting diabetic macrosomia.[15] Song et al in their study of 177 macrosomic neonates found the HC:CC ratio is 1.007 (±0.038) in healthy babies versus 0.993 (±0.043) in babies of diabetic mothers.[14] This correlates with our findings (Table 1 Macrosomia Index and HbA1c)

Many health-care providers have measured HbA1c early in pregnancy and correlated these values with LGA or macrosomia with varying results.[25] In the present study among mothers diagnosed as non-GDM and with HbA1c normal in labour only 3.1% had abnormal MI. These results are similar to Mansani et al who measured maternal HbA1c on the third day after delivery and found neonatal anthropometric values above 90th centile in babies of mothers with higher HbA1c, and concluded that postnatal HbA1c can give valuable information about fetal growth.[25] Mikkelson et all measured HbA1c levels at the time of delivery and found women who did not achieve levels ≤5.6% at delivery had a three-fold risk of having a large for gestational age infants and a six fold increase in risk for neonatal hypoglycemia.[26]

In a study among 507 Asian Indian women it was noted that abnormal OGTT and HbA1c >6% in the first trimester probably represents pre-existing diabetic state but were detected in pregnancy. One group of mothers had normal OGTT but elevated HbA1c, which could have happened due to pregnancy induced disturbances in alimentation but on follow-up all these mothers developed GDM in the last trimester.[27] This is similar to our finding that mothers designated as non-GDM based on one OGTT in the second trimester had significantly high HbA1c and abnormal MI comparable to those with diagnosed GDM.

The other advantage of doing HbA1c in labour is that blood sugars of mothers with high HbA1c can be monitored postpartum. In spite of widely disseminated guidelines, postpartum glucose testing is exceedingly low in GDM groups, thus missing a critical opportunity to prevent and treat type 2 diabetes.[28] The non-GDM mothers with HbA1c >5.4% in our study would have had no postpartum monitoring of blood sugars.

Diagnosis of abnormal MI at birth could enable health-care providers to decide on babies that require blood glucose monitoring in the first 12 hours. Macrosomia occurs in one third of diabetic pregnancies, irrespective of class.[29]

The existing criteria would miss all babies born to mothers with non-GDM status and unknown GDM status weighing <4000g. But our study shows that among the non-GDM mothers (n=481) there were 63.1% (308/715) mothers with HbA1c >5.4% resulting in 18.1% (56/308) of babies with abnormal MI. If only birth weight >4000g was considered as cut-off for monitoring blood glucose then 79 babies with abnormal MI would have been missed. One of the main limitation of this study is the lack of followup of blood glucose in babies with abnormal MI, which is presently now on-going. Study by Van Haltren et al in infants of 326 diabetic mothers showed that hypoglycemic episodes occurred in 33.4% of babies and that macrosomia was seen in 15%. Elevated HbA1c and macrosomia were two of the risk factors for developing hypoglycemia.[30] Other workers have also reported similar findings.[31] Disproportionate growth seems to be a predictor for neonatal complications, hence the need for a macrosomia index.[32]

We recommend that Macrosomia index must be measured in all term babies at birth, in addition to birth weight, and if ≤1, complications, especially neonatal hypoglycemia, should be monitored for at least 12 hours. Future studies are required to prove the validity of macrosomia index by comparing with other anthropometric measurements and by monitoring the immediate post-natal complications of the babies if MI≤1.

In conclusion, abnormal Macrosomia Index (≤1) significantly correlated with an HbA1c of >5.4% at delivery, irrespective of maternal GDM status. This index may be a reliable marker for identifying macrosomic infants of diabetic mothers. Birthweight of >4000g as a cut-off for identifying macrosomia in infants of diabetic mothers, does not appear to be suitable for the South Indian population and may be fallacious.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Jose P, Vani J, Kommu PPK, Kuruvila SK, Krishnan L. Is head to chest circumference ratio a better detector of macrosomia in infants of diabetic mothers as compared to birth weight >4000g? Int J Contemp Pediatr 2017;4:2120-5.